Hierarchical Goal Analysis and Performance Modelling for the Control of Multiple UAVs/UCAVs from an Airborne Platform

Final Report

Volume 1

Bob Kobierski

CMC Electronics Inc.
415 Legget Drive
Box 13330
Ottawa, Ontario
Canada, K2K 2B2

Contract Number W7711-037870/A
CMC Document Number 1000-1303

On behalf of
DEPARTMENT OF NATIONAL DEFENCE

Defence R&D Canada - Toronto

Contract Report
DRDC Toronto CR 2004-063
16 September, 2004

Report Documentation Page			*Form Approved* *OMB No. 0704-0188*
Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.			
1. REPORT DATE **18 SEP 2004**	2. REPORT TYPE		3. DATES COVERED **-**
4. TITLE AND SUBTITLE **Hierarchical Goal Analysis and Performance Modelling for the Control of Multiple UAVs/UCAVs from an Airborne Platform**			5a. CONTRACT NUMBER
			5b. GRANT NUMBER
			5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)			5d. PROJECT NUMBER
			5e. TASK NUMBER
			5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Defence R&D Canada -Ottawa,3701 Carling Ave,Ottawa Ontario,CA,K1A 0Z4**			8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)			10. SPONSOR/MONITOR'S ACRONYM(S)
			11. SPONSOR/MONITOR'S REPORT NUMBER(S)
12. DISTRIBUTION/AVAILABILITY STATEMENT **Approved for public release; distribution unlimited**			
13. SUPPLEMENTARY NOTES **The original document contains color images.**			
14. ABSTRACT **see report**			
15. SUBJECT TERMS			

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**		**577**	

Author

Bob Kobierski, CMC Electronics Inc.

Approved by

Dr. Ming Hou, DRDC-T

DND Scientific Authority

Approved for release by

Jean-Yves Lamarre, CMC Electronics Inc.

HFE Program Manager

This Report is *UNCLASSIFIED* - CMC Electronics Inc. Human Factors Engineering

cmc electronics

Hierarchical Goal Analysis and Performance Modelling for the Control of Multiple UAVs/UCAVs from an Airborne Platform

Final Report
Volume 1 of 2

Bob Kobierski
HFE Design Specialist
613-592-7400 x 2208

Jean-Yves Lamarre
Project Manager
613-592-7400 x 2273

CMC Electronics Inc.
415 Legget Drive
Box 13330
Ottawa, Ontario
Canada, K2K 2B2

PWGCS Contract No.: W7711-037870/A
Report No.: CMC Document Number 1000-1303

On behalf of
DEPARTMENT OF NATIONAL DEFENCE

Defence R&D Canada - Toronto Scientific Authority:
Dr. Ming Hou
Defence R&D Canada Toronto (formerly DCIEM)
1133 Sheppard Avenue W
Toronto, ON, M3M 3B9
416.635.2169

Defence R&D Canada - Toronto

Contract Report
CR 2004-063
16 September, 2004

This page intentionally left blank.

Abstract

Early feedback from the operation of Uninhabited Air Vehicles (UAVs) indicates that improvements in the operator interface aspects of these emerging systems would reap significant gains in system performance and effectiveness. This applies to both effective control of UAVs as well as management of data and dissemination of the associated information. The Canadian Forces (CF) is pursuing the introduction of UAVs, and while such platforms may provide an enormous amount of data, the management of data to support effective human decision making is still an issue. Various levels of automation have been suggested as a way of addressing the problem including Intelligent/Adaptive Interfaces (IAIs) for decision support. IAIs are intended to manage information dynamically and provide the right data and information to the right people, at the right time, to support effective decision making. The work reported in this paper investigated the efficacy of IAIs in an operational situation. The selected environment involved UAV operations in support of counter terrorist activities with the IAI modelled as part of the UAV tactical workstations of a modernized CP140 aircraft.

In order to produce an analysis of UAV operations which are relevant to CF UAV implementation plans, a one hour mission scenario was developed which reflected a portion of the upcoming Canadian Forces Experimentation Centre (**CFEC**) Atlantic Littoral Intelligence, Surveillance and Reconnaissance Experiment (**ALIX**) program. In order to facilitate the development of a performance model implemented in an Integrated Performance Modelling Environment, a Hierarchical Goal Analysis and Operational Sequence Diagrams were prepared for the scenario. The model was run in two modes: one assuming the operators used a conventional interface and the second assuming interface automation using an IAI.

The difference between mission activities without automation (IAI OFF) and with automation (IAI ON) was reflected in the time to complete critical task sequences and in other measures of performance. It was concluded that the operational control of UAVs from an airborne platform was a complex task and workload increased during use of multiple disparate UAV assets. The use of a workstation, which incorporates an IAI mode, permitted operators to continue working under high time pressure, resulting in upper level goals being achieved in reduced time.

Résumé

Les premiers retours d'expérience de l'exploitation d'engins télépilotés indiquent que l'amélioration de certains aspects de l'interface opérateur de ces nouveaux systèmes permettrait de réaliser des gains importants au niveau de la performance et de l'efficacité du système. Cette conclusion s'applique autant à la commande effective des engins télépilotés qu'à la gestion des données et à la diffusiuon de l'information connexe. Les Forces canadiennes (FC) poursuivent la mise en service d'engins télépilotés, et si ces plate-formes génèrent une quantité énorme de données, la gestion de ces données en appui à une prise de décision efficace est toujours un problème. Divers niveaux d'automatisation ont été proposés comme moyens de régler ce problème, y compris des interfaces adaptatives et intelligentes (IAI) pour appuyer la prise de décision. Les IAI visent à gérer l'information de façon dynamique et à fournir les bonnes données et les bons renseignements aux bonnes personnes et au bon moment pour les aider à prendre des décisions efficaces. Les travaux mentionnés dans le présent document examinent l'efficacité des IAI en situation opérationnelle. L'environnement sélectionné a donné lieu à des opérations d'engins télépilotés visant à appuyer des activités de lutte contre le terrorisme, l'IAI étant modélisé pour faire partie intégrante des postes de travail tactiques d'engins télépilotés à bord d'un avion CP140 modernisé.

Afin de produire une analyse des opérations d'engins télépilotés qui s'accordent aux plans de mise en oeuvre des engins télépilotés des FC, on a élaboré un scénario de mission d'une durée d'une heure faisant état d'une partie du programme de renseignement, de surveillance et de reconnaissance du littoral atlantique (**ALIX**) du Centre d'expérimentation des Forces canadiennes (**CEFC**). Pour faciliter le développement d'un modèle de performance appliqué à un environnement intégré de modélisation de la performance, on a préparé pour le scénario une analyse des objectifs hiérarchique et des diagrammes de séquences opérationnelles. Le modèle a fonctionné dans deux modes : dans le premier, les opérateurs utilisaient une interface classique, et dans le second, l'interface était automatisée au moyen d'une IAI.

La différence entre les activités de mission sans automatisation (aucune IAI) et avec automatisation (avec IAI) s'est manifestée dans le temps nécessaire à l'exécution des séquences de tâche critique et dans d'autres mesures de la performance. On a conclu que la commande opérationnelle d'engins télépilotés à partir d'une plate-forme aérienne était une tâche complexe, et la charge de travail augmentait lors de l'utilisation de multiples engins télépilotés disparates. L'utilisation d'un poste de travail comprenant le mode IAI a permis aux opérateurs de continuer à travailler sous de fortes contraintes de temps et d'atteindre les objectifs de niveau supérieur dans un délai réduit.

16 September 2004

EXECUTIVE SUMMARY

Early feedback from the operation of Uninhabited Air Vehicles (**UAVs**) and/or Uninhabited Combat Air Vehicles (**UCAVs**) indicates that nowhere is the need for improvement in these emerging systems greater than in the operator interface aspects. This applies for both effective control of UAVs as well as management of data and efficient dissemination of the associated information products. The Canadian Forces (**CF**) is pursuing the introduction of UAVs, and while such platforms may provide an enormous amount of data, the management of data to support effective human decision-making is still an issue. Various levels of automation have been suggested as a way of addressing the problem. Both the United States Air Force (**USAF**) and United Kingdom (**UK**) have emerging technology programs in Intelligent/Adaptive Interfaces (**IAIs**) for decision support. IAIs are intended to manage information dynamically and provide the right data and information, at the right time, to support effective decision-making.

The principal focus of the work reported herein was to investigate the efficacy of IAIs in an operational situation. The selected environment involved CP140 operations in support of counter terrorist activities, and the associated operator interface within which the IAI was modelled was the tactical workstations of a modernized CP140 aircraft. The Tactical Navigator (**TACNAV**), UAV Operator (**UAV Op**) and UAV Pilot (**UAV Plt**) positions were studied.

In order to produce an analysis of UAV operations that are relevant to CF UAV implementation plans, a one-hour mission scenario was developed which reflected a portion of the upcoming Canadian Forces Experimentation Centre (**CFEC**) Atlantic Littoral Intelligence, Surveillance and Reconnaissance Experiment (**ALIX**) program. Next, a Hierarchical Goal Analysis (**HGA**) was completed using a collaborative process with Subject Matter Experts (**SMEs**). In order to facilitate the development of the Information Processing and Modelling Environment (**IPME**) model, Operational Sequence Diagrams (**OSDs**) were prepared for the scenario. These formed a visual representation of the subsequently developed IPME network. The Performance Model was run in two modes: the first assumed the operators used a conventional interface and the second assumed interface automation using an IAI.

The results of the simulation indicated that the CP140 UAV tactical crew maintained a constant intensity of activities throughout the various levels of increasing workload and task complexity. The difference between mission activities without automation (IAI OFF) and with automation (IAI ON) was reflected in the time to complete critical task sequences and other measures of performance. With goals that required planning the UAV flight paths or search patterns, reduced times were found through the use of the IAI to assist the operator. All goals that required intense verbal communications within the crew were also assisted through the use of the IAI mode. Intelligent agents were modelled to anticipate the communication requirements, and facilitate internal taskings and information transfer using an "intelligent communications agent".

It was concluded that the operational control of UAVs from an airborne platform was a complex task and workload increased during use of multiple disparate UAV assets. The use of a workstation, which incorporates an IAI mode, permitted operators to continue working with a high intensity, resulting in upper level goals being achieved in reduced time.

16 September 2004

SOMMAIRE

Les premiers retours d'expérience sur l'exploitation des engins télépilotés et des engins télépilotés de combat indiquent que les besoins d'amélioration de ces nouveaux systèmes sont les plus grands pour certains aspects de l'interface. Cette conclusion s'applique autant à la commande effective des engins télépilotés qu'à la gestion des données et à la diffusion efficiente de produits d'information connexes. Les Forces canadiennes (FC) poursuivent la mise en service d'engins télépilotés, et si ces plate-formes génèrent une quantité énorme de données, la gestion de ces données en appui à une prise de décision efficace est toujours un problème. Divers niveaux d'automatisation ont été proposés comme moyens de régler ce problème. La force

aérienne des États-Unis (**USAF**) et le Royaume-Uni (**R.-U.**) disposent de nouveaux programmes techniques en interfaces adaptatives et intelligentes (**IAI**) pour appuyer la prise de décision. Les IAI visent à gérer l'information de façon dynamique et à fournir les bonnes données et les bons renseignements aux bonnes personnes et au bon moment pour les aider à prendre des décisions efficaces.

Le principal objectif des travaux dont il est question dans le présent document visait à étudier l'efficacité des IAI en situation opérationnelle. L'environnement sélectionné a donné lieu à des opérations d'engins télépilotés visant à appuyer des activités de lutte contre le terrorisme, l'IAI étant modélisé pour faire partie intégrante des postes de travail tactiques d'engins télépilotés à bord d'un avion CP140 modernisé. Les postes du navigateur tactique (**NAVTAC**), de l'opérateur d'engin télépiloté (**Op ET**) et du pilote d'engin télépiloté (**Pil ET**) ont été étudiés.

Afin de produire une analyse des opérations d'engins télépilotés qui s'accordent aux plans de mise en oeuvre des engins télépilotés des FC, on a élaboré un scénario de mission d'une durée d'une heure faisant état d'une partie du programme de renseignement, de surveillance et de reconnaissance du littoral atlantique (**ALIX**) du Centre d'expérimentation des Forces canadiennes (**CEFC**). Ensuite, une analyse des objectifs hiérarchiques a été effectuée au moyen de la collaboration d'experts en la matière. Afin de faciliter l'élaboration du modèle d'environnement intégré de modélisation de la performance (**EIMP**), on a préparé des diagrammes de séquences opérationnelles pour le scénario. Ceux-ci formaient une représentation visuelle du réseau EIMP qui a été développé par la suite. Le modèle a fonctionné dans deux modes : dans le premier, les opérateurs utilisaient une interface classique, et dans le second, l'interface était automatisée au moyen d'une IAI.

Les résultats de la simulation ont indiqué que l'intensité des activités de l'équipe tactique préposée aux engins télépilotés à bord du CP140 était constante malgré l'augmentation de la charge de travail et la complexité des tâches. La différence entre les activités de mission sans automatisation (aucune IAI) et avec automatisation (avec IAI) s'est manifestée dans le temps nécessaire à l'exécution des séquences de tâche critique et dans d'autres mesures de la performance. Les objectifs nécessitant la planification des trajectoires de vol ou des circuits de recherche des engins télépilotés, le recours à l'IAI pour assister l'opérateur a permis de gagner du temps. Tous les objectifs nécessitant des communications verbales soutenues au sein de l'équipe ont également bénéficié du recours au mode IAI. On a amodélisé des agents intelligents pour anticiper les besoins en communication et faciliter les tâches internes et le transfert de l'information au moyen d'un « agent de communication intelligent ».

En conclusion, la commande opérationnelle d'engins télépilotés à partir d'une plate-forme aérienne était une tâche complexe, et la charge de travail a augmenté lors de l'utilisation de multiples engins télépilotés disparates. L'utilisation d'un poste de travail comprenant le mode IAI a permis aux opérateurs de continuer à travailler sous de fortes contraintes de temps et d'atteindre les objectifs de niveau supérieur dans un délai réduit.

TABLE OF CONTENTS – VOLUME 1

TABLE OF CONTENTS – VOLUME 1

LIST OF ANNEXES

ANNEX **TITLE** **PAGE**

TABLE OF CONTENTS – VOLUME 2

LIST OF TABLES

SECTION ONE – INTRODUCTION

1.1 GENERAL

The emergence of UAVs and/or UCAVs as useful and effective military systems is upon us. The pioneers in the use of UAVs are currently collecting real operational data that will enable the deficiencies of first generation systems to be identified and resolved, and that will identify additional requirements to enable future UAV systems to be more capable and more effective. Early feedback from actual UAV operations in the field indicates that nowhere is the need for improvement greater than in the operator interface aspects of the systems. This applies both for effective control of the UAVs as well as for the management of data, and efficient dissemination of the associated information products. A key aspect of this is the level of automation to be applied to the decision-making processes facing both tactical commanders and UAV system managers.

The Canadian Forces is pursuing the introduction of UAVs and/or UCAVs to provide a new Integrated Intelligence, Surveillance, and Reconnaissance (**IISR**) platform. While such platforms may provide an enormous amount of data, the management of data to support effective human decision-making is still an issue. Various levels of automation have been suggested as a way of addressing the problem. Both the USAF and UK have emerging programs in IAIs for decision support technologies.

IAIs are intended to manage information dynamically and provide the right data and information, at the right time, to support effective decision-making. Such technologies will be integrated into many, if not all, CF systems of the future. Defence Research & Development Canada (**DRDC**) has initiated a multi-year project for the development of an IAI for advanced UAV/UCAV control under Thrust 13i. The aim of this DRDC project is to develop, demonstrate and prioritize enabling technologies that can be applied to an operator interface that will support reduced manning and enhanced performance in complex military systems. This project will also produce a document that will provide preliminary design guidelines for IAIs.

The domain of application for the demonstration part of the project is advanced UAV/UCAV control, focusing on those technologies that increase the ratio of platforms to operator. The project has the following timeline, starting in FY 03/04:

Year 1 Concept development and theoretical frameworks;

Year 2 Interface design and implementation; creation of the simulation environment; and

Year 3 Demonstrate and evaluate the framework for IAIs; draft design guidelines for IAIs; generation of a follow-on Technology Demonstration proposal.

The starting point for the design of any complex system should be analysis. For systems where human functions are predominantly "cognitive", the method of analysis should capture this essentially human activity. It is likely that advanced UAV/UCAV control systems will require operators to interact with automated systems such as intelligent agents/interfaces. The intelligent/adaptive interfaces that are envisioned for UAV/UCAV operators are more sophisticated than the ones that exist in software packages such as Microsoft Office®, and will require knowledge about mission goals, the operator's goals and states, as well as environmental states.

1.2 BACKGROUND

The intense interest in UAVs has been slow to build, however recent advancements in technology have spurred involvement from many countries' research and development (**R&D**) laboratories. Existing structures of military organizations will adapt to make best use of these assets, as will be studied during upcoming CF operations on the east coast of Canada.

1.2.1 Uninhabited Air Vehicles and Uninhabited Combat Air Vehicles

Increasingly, UAVs are being considered for use on monotonous and dangerous missions. The majority of UAVs are used for reconnaissance and surveillance, but there is a growing interest in using UCAVs to deliver weapons directly or indirectly (for example, using a laser to guide weapons delivered from another platform).

Early UAVs were little more than radio-controlled aircraft. Operators flew them from the ground and, by necessity, were required to maintain visual contact with the vehicle. It is said that during the Vietnam War, some UAVs were controlled from airborne platforms, such as helicopters, allowing them to operate over longer ranges while maintaining direct visual contact with the aircraft but little has been written of the difficulties faced by their controllers.

The sensors on most early UAVs were still cameras or movie cameras, and the images were viewable only after the aircraft was recovered. The increasing capabilities of datalinks now allow UAVs to download images via ground or satellite stations, or to deliver these images in real-time. As soon as real-time sensor information became available, the concept of operations evolved, allowing the pilot to relinquish visual contact and operate the UAVs Over The Horizon (**OTH**), at night or even in poor visibility (using weather-tolerant sensors such as radar or active gated laser illumination).

As the quantity and variety of data collected increased, the workload of the operator increased exponentially. Moreover, the data must be integrated to convert it into information and then must be disseminated to those who make decisions. In the recent past data collection; data fusion; information management and distribution; intelligence collecting and data related decision making have threatened to become a bottleneck which is made more complex by increasing joint operations and very rapid and flexible warfare.

An issue still remains regarding the placement of the operators controlling these uninhabited aircraft, and the organization of those who take the data, merge, compare and distribute the data to turn it into information and intelligence. Communications are being developed rapidly, but for the foreseeable future, there is still likely to be a role for airborne operators housed in a mobile platform close to the Area of Operations (**AOO**). The use of helicopters as airborne platforms for UAVs is currently less likely than the use of longer endurance fixed-wing aircraft, such as the Challenger (CC-144), the Hercules (CC-130) or the Aurora (CP140).

1.2.2 Challenges to Military Organizations

The operation of UAVs is likely to challenge the existing structures of the military, especially if this operation is taken to include the capture, distribution and use of sensor information and/or the delivery of weapons. The roles associated with the use of UAVs include those of planning, tasking and monitoring the platform, of selecting, filtering and fusing sensor data, and of distributing data to multiple "clients", converting that data into information and ultimately into intelligence. The simple command and control structure associated with controlling a single platform for a single client, the brigade commander for example, will be severely challenged as the tactical scenario calls for the effective control of multiple platforms collecting intelligence for multiple clients, ranging from the local battalion commander to the strategic "purple" planners located thousands of kilometres away.

Rapid changes are already occurring to the concepts of operations of UAVs resulting from technology innovations and from increasing pressures for a more flexible military structure.

1.2.3 Atlantic Littoral Intelligence, Surveillance and Reconnaissance Experiment

The CFEC ALIX is intended to involve one Medium Altitude Long Endurance (**MALE**) UAV, multiple sensors, beyond line of sight communications via satellite and an analysis of the integration issues associated with UAV operations. MALE UAV sorties will last approximately one day. This exercise will refine the hypotheses developed during the Pacific Littoral Intelligence, Surveillance and Reconnaissance Experiment (**PLIX**) program. ALIX is scheduled to commence in August of 2004.

CFEC is continuing concept development of the Intelligence, Surveillance and Reconnaissance (**ISR**) mission supported with UAVs. Following the successful 2003 PLIX the next experiment will be conducted on the east coast of Canada and will consist of three scenarios stretching from Gagetown, New Brunswick to the east coast of Newfoundland and Pangnirtung on Baffin Island. This experiment will be used to manage and use an IISR Architecture involving information and images from multiple vehicles including UAVs of various kinds. Information transfer and the associated fusion of data to improve the fidelity of the information are key to success of the experiment. The intent is to assess command and control from the strategic level to the tactical level. An unclassified Common Operating Picture is intended with information shared using a knowledge web portal. The CF is involved in this experiment along with a number of Other Government Departments (**OGDs**) including Environment Canada, Canadian Coast Guard (**CCG**), Department of Fisheries and Oceans (**DFO**), and Transport Canada. Additionally, representatives from multiple UK services, the United States Navy (**USN**) and US Coast Guard R&D Center will be present.

1.2.4 Intelligent Adaptive Interfaces

The principal focus of the work of which this project is a part is to investigate IAIs in challenging operational environments. The term "Intelligent Interfaces" is used in the Human Computer Interface (**HCI**) field, whereas the term "Adaptive Interfaces" is used in the Human Factors Engineering (**HFE**) field. The term "interface" refers to the operator interface, which would be used by the military personnel conducting an IISR mission. In this case, the operator interface is contained within a tactical workstation in a CP140 aircraft, and the point of interest for this comparative analysis is the workstation Graphical User Interface (**GUI**) and associated software.

IAIs help reduce usability complexity. These interfaces automatically adapt to each user, contrary to adaptable interfaces where the user has explicitly to adjust the interface. Such interface aids are being investigated as potential means of reducing the workload and increasing both the pace and effectiveness of the operation. Interfaces must be adaptive to allow the user to accomplish more, faster and with fewer errors.

DRDC has initiated a project for the development of IAI for advanced UAV control and wishes to evolve their testbed to develop a system capable of identifying goals, recognizing plans and generating complementary plans to aid users in complex operational environments. This report takes previous work one step further with a HGA based on Perceptual Control Theory (**PCT**) [Ref. 1] and an IPME Network Model allowing comparisons between operations with and without IAIs.

1.3 PROJECT OBJECTIVE

The objective of this project is to produce a HGA and Network Model based on a mission composite scenario involving controlling multiple UAVs from an airborne platform. The network model is to be used to evaluate the IAIs during three portions of the mission involving increasing levels of workload.

1.4 PERCEPTUAL CONTROL THEORY

In traditional HFE analyses, the operational activities were described as a hierarchy of action-based functions that were then allocated to human operators or a hardware or software "machine". Functions allocated to the human operators were referred to as "Tasks", and "Critical" tasks were further analysed to provide data for the design of equipment and Operator Machine Interfaces (**OMIs**).

PCT, espoused originally by Powers [Ref. 1], recognized that many of the functions identified previously by the traditional "Function Analysis" were often defined by the goals of the system. PCT scientific researchers (including those at DRDC Toronto) suggested analyzing missions as hierarchies of goals; nested, sequenced or otherwise linked into logical networks, which could then model and predict activities.

William T. Powers suggests that all human behaviour occurs as a result of a perceptually driven, goal referenced, feedback system. Hendy et al advise that this is the tenet for PCT that at best provides a truthful explanation of how humans form and emit behaviours; at the very worst PCT is a normative model of human behaviour. The PCT model suggests a multilayered system, with multiple goals providing the reference points for a hierarchical organization of control loops.

DRDC Toronto has been active at developing tools to allow PCT analyses to be undertaken [Ref. 2]. With this as guidance, the overall scope of the work reported herein was to prepare a mission scenario, analyze the goal hierarchy and from it to develop a Performance Network Model in IPME for delivery to DRDC Toronto. The Network Model provides functionality sufficient to allow operator performance and effectiveness to be compared with and without IAIs. The longer-term objectives are to use these tools to guide doctrine and to guide experimentation within existing simulation capabilities.

IPME is a discrete event simulation framework used to model and assess human and system performance. It is comprised of an environment model, a crew model, a task network, a performance-shaping model and optional external models. Combined with IPME's scheduling algorithm, these models can help an analyst accurately predict workload and operator performance. Analysts can use one of IPME's three execution modes: IPME mode, Prediction of Operator Performance (**POP**) mode and Information Processing/Perceptual Control Theory (**IP/PCT**) mode. While the IPME and POP mode address workload using the performance shaping functions, the IP/PCT mode uses an algorithm, the Information Processing (**IP**) scheduler, to adjust operator performance based on various factors such as time pressure, task criticality and task conflicts. The analysis reported herein has been completed using the IP/PCT mode of IPME. Annex E contains a detailed description of the application of PCT in the IPME software.

The task network is based on the Micro Saint simulation engine and is comprised of a simple interface used to define tasks behaviour, operator assignment and interactions between tasks. By linking together various networks or tasks, the simulation developer can create a model replicating the behaviour of a real system. Through the various tabs, the function list and the variable catalogue a developer can define the behaviour of each individual task. In IP/PCT mode, additional tabs are available to allow the simulation developer to define critical IP/PCT parameters such as task priority.

1.5 REFERENCES

1 Powers, W.T. (1973) *Behaviour: The control of perception*. Aldine De Gruyter, New York

2 DCIEM (1997) *Implementing a Model of Human Information Processing in a Task Network Simulation Environment*, Report No. 97-R-71

3 Greenly and Associates (2003) *Operational Mission and Scenario Analysis for Multiple UAVs/UCAVs Control from Airborne Platform,* Defence Research & Development Canada Toronto Contract Report CR 2004-061, May 2004.

4 Moore, T. and Kelleher, D. (2003) *Concept of Control of Unmanned Air Vehicles (UAVs) and Unmanned Combat Air Vehicles (UCAVs) from Airborne Platforms* Defence Research & Development Canada Toronto Contract Report CR 2004-063, May 2004, Kanata, ON, Canada: CMC Electronics

5 *System Operator Loading Evaluation, Vers. 3.0 Methodology Documentation*, 8 January 1993, Canadian Marconi Company

6 Dr. Moira Smith, C.R. Angell, M.L. Hernandez, W.J. Oxford, *Improved Data Fusion Through Intelligent Sensor Management,* in: Proceedings of AeroSence Conference, Signal Processing, Sensor Fusion, and Target Recognition XII, 2003.

SECTION TWO – METHODOLOGY

2.1 GENERAL

This section includes a description of the development of the UAV scenario used for this project, the HGA and associated IP/PCT network, and the conduct of the model data collection.

2.2 UAV SCENARIO

In order to produce an analysis of UAV operations that are relevant to CF UAV implementation plans, a decision was made at the project Initial Meeting to develop a mission scenario that reflects the upcoming CFEC ALIX program.

As a first step in the analysis a one-hour scenario was developed. This activity commenced with an extensive SME session with the CFEC individuals involved with the ALIX program. A minute-by-minute description of the scenario was produced, along with plots of the mission evolution, and a CF SME who has extensive CP140 and UAV experience reviewed the results.

2.3 HIERARCHICAL GOAL ANALYSIS

Like a task analysis, an HGA requires the creation of a decomposition of goals from the highest level (for example, GOAL = counter terrorist mission is completed) down to lower and lower levels. In PCT terms, goals must be defined in perceptual terms (for example, the operator will achieve the goal when they perceive that "the counter terrorist mission has been completed"). A Hierarchical Goal Analysis was achieved by developing the goal analysis using a collaborative process with SMEs.

The CMC Electronics Inc. (**CMC**) HFE Team produced an HGA general architecture using a top-down approach. Prior to proceeding with an in-depth decomposition to lower level goals, the general architecture was reviewed with the Scientific Authority (**SA**). These work items are described in more detail in the following paragraphs.

The generation of the general architecture commenced with a review of *Operational Mission and Scenario Analysis for Multiple UAVs/UCAVs Control from Airborne Platform* [Ref. 3], a review of relevant references, and a discussion session with the SA at the Initial Meeting. This review complemented knowledge gained during the preparation of the CMC report, *Concept of Control of Unmanned Air Vehicles (UAVs) and Unmanned Combat Air Vehicles (UCAVs) from Airborne Platforms* [Ref. 4]. Additionally, CMC has initiated an internal research effort into UAV operations and associated systems and subsystems. This library of information was studied ensuring that the team was as up-to-date as possible with regards to current UAV functionality. The document review period provided the information needed to establish an accurate foundation for the functional architecture.

The Top Level HGA was presented to the Department of National Defence (**DND**) SA and a methodology expert from CFEC to ensure that this important first step in the creation of the architecture is well accepted by both the SA and individuals who will contribute to the project at a later date. The discussion was documented so that the information shared was available to the CMC Project Team. As the composite scenario was prepared, the CMC analysts recorded the goals determined for the three CP140 crewmembers responsible for UAV control. As an upper level goal was conceived of, lower level goals were also recorded, at least to the second level.

The decompositional goal analysis was based on the architecture developed in the previous work item. The Team decomposed the First and Second Level Goals from the mission (representing approximately 1 hour of operational time) to the 3rd or 4th level, as necessary, to establish and refine operator goals for modelling at the appropriate level to establish the benefits of IAI.

Functional groupings, which relate to the general architecture, were reassessed during the decomposition process. It was necessary to have a comprehensive understanding of the challenges of using UAVs "in-theatre" in order to establish effective functional groupings for the model at all levels.

Within the top-down HGA, the following information was determined:

a. Goal label;

b. whether the goal is an IAI candidate;

c. PCT influenced variable;

d. operator assignment; and

e. range of goal completion times for each time the goal was achieved.

Once the composite mission scenario had been completed and reviewed by the DND SME and the top down HGA reviewed by DND, the bottom-up goal analysis was commenced. For each minute of the scenario, all lowest level goals (tasks) were identified for the TACNAV, UAV Operator and the UAV Pilot. Additionally, relevant tasks of the balance of the CP140 crew were documented, along with Canadian Patrol Frigate (**CPF**), Maritime Operations Center (**MOC**) and Regional Operations Center (**ROC**) tasks that were necessary to progress the scenario. As the work proceeded, tasks were identified for the whole one-hour scenario. These were grouped into upper level goals.

Similar information to that listed above was reported for the bottom-up HGA, although in this case the tasks only occur once at a point in the scenario therefore only one completion time is reported. The same goal may be undertaken at another time in the scenario (as identified by a different and unique task number) and the completion time may be different depending on the operator undertaking the task and mission circumstances.

2.4 PERCEPTUAL CONTROL THEORY DATA

The inventory of goals created while performing the work items described above was allocated to an operator or a system. In the network, there will be goals that will be allocated to the operators exclusively, and other goals that may be allocated to a machine, most notably to an IAI. The performance model was run in two modes: one with an IAI and one without. Allocation of goals to the operator or the IAI was based on analysts' subjective review of allocation criteria similar to those contained in the CMC SOLE Methodology User's Guide [Ref. 5].

In order to facilitate the development of the IPME model, OSDs were prepared for the one-hour scenario. The OSDs provided a visual representation of the IP/PCT network that was suitable for HGA review and model network production.

The project team produced a descriptive label for each goal in the HGA. The last work item associated with conducting the HGA was to populate an IPME database. In addition to the goal label, the database included predecessor and successor tasks and the required condition for goal achievement. Goal completion times (mean and standard deviation) were estimated by CMC experts and reviewed by DND. Also, parameters were included that may interfere with the successful completion of a goal.

The data fields required within IPME were used to guide the selection of items necessary for description of the UAV operators' goals. Each goal was studied to ensure that the IPME data was complete, including: completion times; beginning and ending effects; behaviours; associated effects on other parameters, values and variables; task criticality; and visual, auditory and cognitive and psychomotor categories.

Tasks that were chosen as IAI tasks were assumed to involve the same IP/PCT values, although due to the type as intelligent assistance afforded the operators, a task completion time of 10% of the original value was assumed.

2.5 IPME AND IP/PCT TASK NETWORK MODELLING

Following the preparation of the HGA, the CMC Team completed a Performance Network Model. This initial network was fully exercised using all work items described in this subsection, and the results were reviewed with the SA.

CMC generated a design or architecture in the IPME for the UAV operators. The Team used a sequential type of operationally based model that has traditionally been prepared for DRDC.

2.5.1 Determine MOEs and MOPs

Measures of Effectiveness (**MOEs**) determine aspects of the systems capability to meet operational requirements. These might be related to the quantity and/or quality of information collected (for example, accuracies of target - terrorist boat - position versus time, or the accuracy of the UAV EO automatic tracking device). Measure of Performance (**MOPs**) relate to measures which ultimately may affect the effectiveness of a system, but which do so only indirectly. These may include measures of the performance of an operator (such as time to complete an upper level goal, e.g. "I want to perceive that VTUAV 1 employment has been planned"), or the performance of a piece of equipment used by an operator (such as number of operator tasks shed due to high workload with a conventional interface versus an IAI).

MOEs and MOPs are the ultimate means to assess how well systems meet design requirements or how an experimental variable affects outcomes. During the preliminary analysis, it was determined that MOEs for the UAV mission were operationally oriented and were not able to be directly correlated to IP/PCT Goal Analysis output. For example, there is no IPME output that describes the accuracy of the target tracking system. For this reason, network model MOPs were used exclusively and these were selected to be both operationally relevant and technically feasible. Considering that the project produced a model that compares missions conducted with and without IAIs, the MOPs also had to provide a means of assessing the merits of incorporating the new technologies. Additionally, the measures had to give a clear indication of the most fruitful areas for further research and development. Finally, this was the first opportunity to incorporate a full PCT evaluation of two design options involving differing levels of interface complexity, and the output had to allow the merits of the PCT to be fully exercised.

The MOPs that were used in the analyses include:

a. completion times for critical sequences (Upper Level Goals);

b. period of time (in a sliding one minute window) each operator had to interrupt, shed or delay a task;

c. number of goals ongoing;

d. instantaneous time pressure; and

e. number of tasks interrupted, shed or delayed.

Item (b) above is similar to the Task Conflict Parameter produced as an output of the IPME network model (see Annex G); however in this subsection the measure refers to one evolution of a mission, and the Task Conflict Parameter of Annex G refers to data summation for many runs (10 in this case) of the model. The period of time herein is measured as a percent of a sliding one minute window (plus and minus 30 seconds), and the Task Conflict Parameter is the mean value, at any second of the mission, of these percentages.

Following production of the list of potential MOPs, these were reviewed with the SA.

2.5.2 Develop IPME Network Model

The network model was based on the HGA described in Subsection 2.3, inventory (hierarchy) of bottom-up goals, OSDs and all PCT data collected while carrying out the previous task. The analysts used the OSDs of Annex C as the basis for the IPME network. The OSDs related all bottom-up lowest level tasks in a temporal sequence. The HGA was used to complement the development of the IPME network by ensuring that all-important goals were included in the scenario. The HGA is a functional decomposition rather than a temporal sequence like the OSDs and, as a result, was used more as a verification vehicle rather than as a starting point for the network. Both the top-down HGA and bottom-up inventory of lowest level tasks were important to development of OSDs and the IPME network.

A dynamic model was developed with three or four levels of decomposition as introduced earlier. The network development involved a staged production of networks, developing the final architecture using a phased approach. Part One of the scenario was generated by CMC staff, Part Two was completed by Micro Analysis & Design and then Part Three was undertaken by CMC.

A reassessment of the MOPs was conducted as the networks were produced to ensure that the assumptions used for the initial production of these measures were still valid. In addition, the list of operator goals was reviewed and the goals were augmented or modified if necessary to reflect the Team's continued appreciation of the UAV crew's activities.

A random number generator seed was be established and inserted. Although the network model is a UAV operator model, external events (other aircrew member activities, UAV activities and other unit activities) had to be established to allow the network to function. These were prepared and included in the network.

2.5.3 Task Networks

Tasks and networks were added methodically and tested in phases to facilitate the model validation process. The model was built in two minute increments and then validated. Once a two minute segment had been validated, the next two minutes were developed. This development approach ensured that the model would exhibit the behaviour defined by the operational sequence diagrams. CMC used the task structure defined in the operational sequence diagrams to build the task network model. The operational sequence diagrams do not consider factors that may result in the shedding, delaying, interrupting or prolonging of tasks. Thus, to facilitate the validation process, CMC chose to develop a preliminary model in IPME mode. In IPME mode the results of the model's execution can easily be mapped against the structure defined in the operational sequence diagrams. All of the data required to run the model in IPME mode such as the mean time and operator assignments was provided in the OSDs.

After validating the model against the sequence diagrams, CMC added PCT parameters for each task in the model. Parameters such as task priority and resource allocation were determined by an operations expert. The model was run in IP/PCT mode and data was collected.

2.5.4 Network Output

IPME contains built-in data collection and reporting capabilities. The data CMC collected was used to analyze the model's (operator's) behaviour and determine the effects of using IAI on the operator's performance.

CMC decided to use IPME's snapshot capability to record the execution time required to conduct the goals associated with a task network. This data allowed the analyst to compare the time required to achieve a goal with or without IAI. In addition to these snapshots, CMC used the IP/PCT reports generated by IPME. By looking at the tasks shed, tasks delayed, tasks interrupted, and instantaneous time pressure CMC was able to isolate factors affecting an operator's performance when aided by an IAI system.

These outputs allowed the analysts to determine how an IAI system would affect an operator's ability to achieve an objective. Combining goal execution times with tasks shed data, enables the analyst to determine how the IAI system improved the operator's performance.

SECTION THREE – RESULTS AND DISCUSSION OF RESULTS

3.1 GENERAL

This results and discussion of results section contains details associated with the UAV Scenario, HGA and IP/PCT Modelling.

3.2 UAV SCENARIO

The UAV Scenario, which was prepared as the first step in this project, is contained in Annex B. In order to ensure that the analysis evolved in accordance with DRDC Toronto's multi-year program, the initial scenario concept was reviewed by the SA, and requirements were developed for the extent of the scenario. It was determined that three parts were to be prepared, each with a 20 minute duration. This allows subsequent creation of an experiment (during Year 2) with three levels of workload. The scenario begins with a fictitious advanced security briefing to Commonwealth Heads of Government Meeting (**CHOGM**) security staff, conducted in February 2011. Following this, a description of the situation on the day of the opening of the CHOGM is provided, as well as a brief overview of the one-hour scenario. This overview established a terrorist threat that was probably located in a boat off the coast of Newfoundland. A detailed description of the scenario completes Annex B, along with illustrative figures contained within the text.

The first 20 minutes of the scenario is considered to be low workload in that the UAV crew has only one UAV to control (a Vertical Take-off UAV [**VTUAV**] previously launched from a CPF), along with one fishing trawler (designated Contact 1) to be viewed by the CP140. Following initial system check-out, the VTUAV is required to approach and record video on one potential terrorist trawler (designated Contact 2), which is found to be conducting normal fishing activities.

During the second 20 minute period of the scenario, the crew has a greater workload. The CP140 crew drop a Mini UAV which the crew must control in addition to the VTUAV. The Mini UAV investigates Contact 4 which is a trawler fishing illegally in that it has started fishing prior to the opening of the fishing area. At approximately the same time, the VTUAV is tasked to search for a new contact, designated Contact 5. The location of this contact is not well known and the crew find three boats that may be Contact 5. These are referred to a Boat 1, 2 and 3 in the scenario. At the request of the UAV crew, a MALE UAV in the vicinity is used to image Boat 2 using Inverse Synthetic Aperture Radar (**ISAR**) while the VTUAV investigates Boat 1. During the same 20 minute period, the MALE UAV also investigates Contact 3, which is the last of the original 4 contacts to investigate. At the end of the second 20 minute period, only Boat 3 is left to investigate.

The last 20 minute period of the one-hour scenario begins with the crew losing contact with the VTUAV. It is unclear why the VTUAV is lost, and to investigate, the CP140 releases 3 Mini UAVs over Boat 3. At the same time, two CF-18s are tasked to close on the area. This high workload period is accentuated with the release of two more Mini UAVs, ISAR imaging by the MALE UAV and in introduction of a second VTUAV. As the scenario continues, Boat 3 is identified as a terrorist vessel that launches a Lethal UAV towards the CHOGM in St. John's. The Lethal UAV is armed with a "dirty" bomb. The UAV crew on the CP140 have a decision to make regarding the impending CF-18 attack, because there is no reason to attack Boat 3 if it is no longer a threat. This prompts considerable activity within the CP140 crew. The scenario concludes at 60 minutes as the CP140 leaves the area to search for the Lethal UAV that has been launched. As can be seen by this short description of the third part of the scenario, this is the high workload period.

There was also a requirement to provide, within the scenario, three levels of complexity in order to assess the efficacy of IAI across three levels of workload and three levels of job complexity. This was accommodated by involving three members in the UAV crew. The UAV pilot was given the least complex role in that he only had to plot the UAV routes and monitor the UAV systems. The UAV Operator was given the responsibility of ensuring that the UAVs were positioned correctly to view the boats and that sufficient and valid video images were recorded to complete the mission. Finally, the TACNAV was given the most complex role, in that he was required to plan and oversee completion of the mission using both the UAV crew and the rest of the CP140 crew. The complexity of the TACNAV's role was especially evident in the third part of the scenario when difficult decisions must be made regarding attacking a boat which may be neutral or unarmed.

3.3 HIERARCHICAL GOAL ANALYSIS

The results of the Hierarchical Goal Analysis are contained in Annex C. This annex contains two forms of a hierarchy of goals, the first done early in the project and consisted of a top-down analysis of goals, and the second done during the development of OSDs and is considered a bottom-up approach. It was found that the top-down analysis was initially incomplete and it was not until the mission activities had been studied in detail that the total list of top-down operator goals could be produced. The OSDs are provided in Annex D along with a description of how to interpret an OSD.

The Top-Down HGA includes all goals that were initially determined during the top-down analysis and those which were added later when the more stringent bottom-up approach was completed. The tasks identified in the Bottom-Up Goal Analysis were used during the generation of the OSDs. Review of theses diagrams resulted in the list of bottom-up goals increasing by approximately 20 percent as the OSDs were evaluated for completeness. Although there are no specific results to report regarding the number of additional goals added to the top-down list, this figure is also approximately 20 percent. Each task represented in the OSDs may occur many times during the one-hour scenario and as a result, each top-down goal may correspond to many bottom-up goals. All top-down goals which were determined but not used in the scenario are identified as such in Annex C.

Of particular interest is the identification of goals that are candidates for IAI. These are recorded in the top-down HGA and, because many tasks in the OSDs may correspond to a top-down goal, if any one was determined to be appropriate for automation (IAI), the top-down goal was identified as a candidate. The incorporation of automation into the scenario was completed following the generation of the OSDs. This was well on in the project and followed preparation of the scenario, top-down HGA, bottom-up HGA and the OSDs themselves. At this point, the CMC engineers completed a review of numerous articles found in open literature via a web search using the keywords "intelligent AND adaptive AND interface" and the documents listed in Subsection 1.5, References. These engineers then reviewed each OSD task to determine if it was an appropriate candidate for IAI. Advice was sought from the SA, who indicated that at this point the algorithm used to choose an IAI task should not be overly complicated. This would be the subject of further research; rather, clearly identifiable tasks should be chosen. Specifically, the CMC engineers chose tasks that related to a system that had intelligence or was an expert system. Therefore, tasks that the system would have no indication of could not be identified as IAI tasks. For example, an incoming verbal tasking from the MOC could not result in the initiation of an IAI task because the CP140 system would not be aware of the contents of the message. On the other hand, the system would track keystrokes and cursor movement and would be able to deduce that an operator was attempting to complete multiple concurrent tasks. In this case, the interface could adapt to the situation and provide partial or complete assistance to the overworked (over-tasked) operator. For example, the interface may include provision of potential UAV search patterns if the busy operator has UAVs airborne and untasked due to high operator workload.

In the final analysis, two types of tasks were identified as IAI tasks. First, activities that were based on route planning were chosen as IAI tasks. Recent investigations by the CMC team determined that currently data fusion software is being produced which determines a "figure of merit" for the flight path of multiple UAVs viewing a moving target, with multiple on sensors onboard the UAVs. The author of this research, Dr. Moria Smith of Waterfalls Solutions, UK, advised that within one year it is reasonable to expect that software will be available, which could plot suitable routes for UAVs to maintain good tracking solutions of single targets. Her work for the UK Ministry of Defence is more extensive and further investigations would be worthwhile [Ref. 6],

The second type of task chosen as an IAI task was a communication tasks for which information regarding the upcoming communication was available to the IAI subsystem. In general, verbal communications are preferred, providing that the crewmembers are not over-tasked; however, when a commonplace communication is initiated which interrupts the recipient while that person is engaged in a complex cognitive task, the communication is detrimental. As a result, during high workload periods and when the data is available for the system to facilitate communications, an "intelligent communication agent" should augment or facilitate transfer in directions or information. For example, based on the OSDs it was determined that whenever the TACNAV inserted a fly-to waypoint for a UAV which was just about to be launched, he would advise the UAV Pilot that the waypoint was inserted and give the general location of the waypoint. During low workload periods, this transfer of information is good to accomplish verbally because the TACNAV can immediately verify that the UAV Pilot understands and is in agreement with the tasking. During high workload periods, this message may be lost, forgotten or misinterpreted. It has been assumed that, for the purposes of this analysis, the IAI would initiate the communication by setting a flag with the information on the TACNAV's workstation that would be sent when the TACNAV initiates transmission with the touch of a function key. This stimulus-response TACNAV task would be non-intrusive and would transfer this internal

IAI message to the UAV Pilot for him to review at his earliest opportunity and without interference.

It was found that the HGA for the one-hour scenario, involving 3 UAV crewmembers in the CP140, was initially incomplete when the goals were only identified using a "top-down" approach. Once OSDs were produced, the list of operator goals was expanded significantly. This finding was unexpected at the time, however after the fact was considered quite normal. SMEs, especially individuals who have been part of a training organization, are trained to think operational tasks through in a logical sequence, from an initial stimulus to goal completion. As a result, it is easy for an SME to identify mission activities in a temporal reference frame (OSD), and once a group of tasks is created, variations of these tasks could also be identified. It was more difficult, during the top down HGA development, to ensure that all goals were found because the SMEs could not imagine themselves conducting a mission. Once the OSD tasks had been itemized, the analyst related each to the corresponding HGA goal. When a goal was missing from the HGA, it was added and all relevant upper level goals were added as required.

3.4 IPME AND IP/PCT TASK NETWORK MODELLING

The OSDs were translated into IPME networks that are contained in Annex F, and the results of the IPME and IP/PCT modelling are contained in Annexes G, H and J. These results are described in the following subsections.

The results of the analysis presented herein are provided as a result of running the network model ten times and recording results. In order to interpret the results, it is important to correlate the portions of the scenario that include IAI tasks. Not all upper level goals contain IAI tasks and as a result, there will be no improvement in MOPs for these portions of the scenario. Table 1 contains a listing of upper level goals that contain IAI tasks.

Table 1 Upper Level Goals with Associated IAI Tasks *

Scenario Part One	Scenario Part Two	Scenario Part Three
140 ... VTUAV route planned to next contact	120 ... VTUAV 1 employment has been planned	230 ... the crew is briefed on the response to lost of VTUAV 1
170 ... CP140 is en route to contact **	206 ... plan for investigation of Contact 4 using a Mini UAV	260 ... CP140 is approaching Boat 2 **
234 ... CP140 approaching and identifying Contact 4 **	330 ... MiniUAV1 is deployed	265 ... handover of VTUAV 2 is completed
376 ... VTUAV route initiated and flown	360 ... Boat 1 is classified	278 ... Mini UAVs 2 to 5 are readied for launch
386 ... Contact 2 is identified using the VTUAV EO	416 ... Mini UAV is investigating Contact 4	315 ... deployment of Mini UAVs 2 to 4

Table 1 Upper Level Goals with Associated IAI Tasks *

Scenario Part One	Scenario Part Two	Scenario Part Three
400 ... the target of opportunity is investigated	428 ... Boat 1 is identified and determined to be neutral	325 ... CP140 is approaching release point for Mini UAV 5 **
486 ... VTUAV refuelling is planned	447 ... investigation of Cont. 4 by MiniUAV1 has commenced	385 ... Mini UAV 5 is employed over the downed VTUAV 1
	500 ... identity Contact 4 is determined using Mini UAV1	510 ... control of the Laser UAV is established
	535 ... illegal fishing activities of Contact 4 are reported	526 ... reassessment of need to attack terrorists is completed
	640 ... VTUAV 1 is approaching Boat 2 and preparing for EO Rig of boat **	556 ... search for the Lethal UAV is discussed and search plan initiated
		574 ... all UAVs are set to autonomous mode to allow CP140 to commence search

* Note: The Upper Level Goals contained in the IPME network are identified by the task number of the first task in the sequence of tasks that make up the crew activities required to complete the goal. Please see Tables 3, 4 and 5 for a complete list of all Upper Level Goals contained in Parts 1, 2 and 3 of the scenario.

** Note: Goal completion times are dependent on the CP140 or UAV flight track rather than the concatenated task completion times. As a result, for these Upper Level Goals performance measures dependant on goal completion times should be deemphasized.

3.4.1 Task Networks

CMC produced a task network model designed to evaluate the performance of an operator when aided by an IAI system. As stated earlier, this task network followed the structure defined in the OSDs. Containing three levels of decomposition, the task network model contained operator goals (tasks). In general, the goals resided on the third level of decomposition although some goals were identified at the fourth level of decomposition. The IAI can assume the responsibility of conducting goals or tasks depending on the objective. This resulted in a model containing an upper level goal for each task network and a series of task networks containing operator tasks.

3.4.2 Normalized Data Plots

In Annex G, the Task Network Output consists of plots of three variables normalized against the mean mission timeline. The first variable is Mean % Occurrence of a Task Conflict which presents normalized data of the mean value, over 10 runs, of the operator's task conflict (as indicated by a task being placed in short term memory). The term "normalized" means that the respective plot of each of the 10 runs of the model is temporally adjusted to match the mean mission time. The plot data is aligned or tied to the start point of all non-overlapping upper level goals. This data reduction was completed with custom written software produced specifically for this project. The Task Conflict Parameter is defined as, for each run, the percent of time during a sliding one minute window that the operator must interrupt or delay a task. For example, referring to page G.3 at six minutes into the mission, on average over 10 runs of the model, the TACNAV had a task conflict that occupied 18% of a sliding one minute window of time. This plot is conservative because tasks shed only appear in the data on the second that they are delayed and no significant time is documented for shed tasks. The second variable plotted in Annex G is the average number of ongoing operator tasks, normalized over the mission time line. The IP/PCT scheduler limits the number of operator tasks to two tasks with a significant cognitive component (see Annex E), although additional less intrusive task may be allowed. Again referring to Annex G, page G.4, at approximately six minutes into the mission, the TACNAV has two task occurring at the same time. This matched the previous plot that indicated that additional tasks had been placed in short term memory at this time. The final plot of Annex G is the IP/PCT Instantaneous Time Pressure. During the time that this data was collected, Micro Analysis & Design advised that mean values of the Instantaneous Time Pressure were questionable. As a result, CMC use the Time Pressure contained in the ".ipr" output file and calculated the second-by-second average Instantaneous Time Pressure from 10 runs of the model. This data were normalized and plotted in Annex G. For example, referring to page G.5, at six minutes into the mission, the TACNAV experiences a time pressure exceeding 1.0 (see Annex E for the definition of time pressure) for approximately 10 seconds. This correlated with the information presented on pages G.3 and G.4.

Information is presented in Annex G for each of the three UAV operator of the CP140 crew, for each of the three parts of the scenario, for each of the three variables introduced above - each with a conventional interface (IAI OFF) and again with IAI ON.

The results shown in the first three pages of Annex G are representative of all UAV operators over the first part of the scenario. First, there is little change in the Task Conflict Parameter indicating that the crew were dealing with multiple tasks with IAI ON and OFF some of which were interrupted or delayed due to task conflicts. However, in the Number of Ongoing Tasks plot and the Instantaneous Time Pressure plot it is clear that the mission evolved much faster with the IAI selected ON. Which clearly indicates an advantage with the use of IAI in that reduced goal completion times leaves more planning and problem solving time. Part Two of the scenario yielded different results. The Task Conflict plots showed that with IAI mode selected ON the operators were dealing with fewer task conflicts. However, the total mission time was not shorter. Finally, in Part Three of the scenario the Task Conflict Parameter is less, but not as significantly reduced as Part Two and the time to complete this part of the scenario is also less, but not as dramatic as Part One. The difference is attributed to the maturity of the network, in that the Part Three network was completed last and was better representative of actual operations.

In all three parts of the mission, the IAI mode showed improvement over use of the non-IAI or conventional interface. Although these data do not conclusively indicate that an IAI is preferable over a conventional interface, they start to show a pattern that is enforced in the discussions of subsections 3.4.3 and 3.4.4.

3.4.3 Summary of Tasks Interrupted, Delayed and Shed

Annex H contains information regarding tasks interrupted, delayed and shed during operations with a conventional interface and with IAI selected ON, for each of the three parts of the mission scenario. There are 16 tables in this Annex rather than 18, because in Part 3 of the scenario there were no tasks shed with either IAI ON or OFF.

There is a considerable amount of information in this Annex and even more information not available, for example, the period of time that each task was prevented from occurring is not available from the model. Table 2 contains, for each part of the scenario, the gross number of tasks that were interrupted, delayed or shed. These results are consistent with Subsection 3.4.2, in that with IAI mode selected ON there is a reduction in the number of tasks that are prevented from occurring at the point in the mission when all associated task initiating conditions are satisfied.

Table 2 Summary of Tasks Interrupted, Delayed and Shed

Scenario Part	Task Effect	IAI Mode OFF	IAI Mode ON
Part One	Tasks Interrupted	29	26
	Tasks Delayed	36	29
	Tasks Shed	15	13
Part Two	Tasks Interrupted	102	97
	Tasks Delayed	161	149
	Tasks Shed	72	70
Part Three	Tasks Interrupted	47	38
	Tasks Delayed	68	63
	Tasks Shed *	0	0

* Note: During the third part of the scenario no tasks were shed with the IAI mode selected ON or OFF. This outcome was the result of the development of the OSDs such that they incorporated task conflict alleviation techniques that avoided the shedding of tasks. This was unintentional in that it meant that this parameter could not be used for the pairwize

comparison of IAI ON or OFF. In addition, these workload measures should not be used to compare the workload of one part of the mission to another because, as indicated in the methodology section, different personnel produced the IPME networks for each part of the scenario. The intent was to produce networks that allow comparison of each part of the mission with the IAI mode selected ON and OFF. This was strictly enforced during the development of the networks.

3.4.4 Upper Level Goal Completion Times

The completion times for all upper level goals of the three parts of the scenario are contained in Annex J. This annex includes data for each of the 10 runs of the model and summary mean values averaged over the 10 runs. The following three tables summarize these data. The upper level goals of interest are listed in Table 1 and are highlighted in Table 3 through Table 5 using three asterisks (***) following the goal title. The results shown in these three tables indicate that, as expected from the preliminary analyses, the greatest advantage of using the IAI Mode of operations appears to be a reduction in the time required to complete upper level goals. For example, the first goal listed in Table 3 involves planning the route of the VTUAV to the next contact. The time to complete this activity is modelled to be approximately 25 seconds less or in other words, a reduction by more than 50%. This is complimented by modest reductions in the Task Conflict Parameter (Subsection 3.4.2) and the reduction in the number of tasks interrupted, delayed or shed (Subsection 3.4.3).

As introduced in the methodology section, the network model is a probabilistic model that used a random number generator to carry out Monty Carlo simulations. The model was run 10 times and the output combined. As a result, due to the probabilistic nature of the model, there is a randomness to the output that may produce goal completion times greater (by a small amount) with IAI selected OFF. This is normal.

Table 3 Part 1 – Goal Mean Completion Time Summary

Goal	Goal Mean Completion Time (Sec) IAI OFF	Goal Mean Completion Time (Sec) IAI ON
140 ... VTUAV route planned to next contact ***	47.8	21.3
142 ... CP140 route planned to next contact	5.4	5.8
144 ... UAV crew taking control of the VTUAV	838.1	671.4
150 ... threat is assessed	77.3	76.3
153 ... tactical crew reorganized	30.4	28.6
154 ... crew workstations configured	35.5	34.0
159 ... terrorist mission tasking acknowledged	54.9	57.5
170 ... CP140 is en route to contact	180.8	173.8
212 ... VTUAV route initiated by UAV crew	123.9	133.7
234 ... CP140 approaching and identifying Contact 4	114.1	115.4
246 ... estimate of VTUAV time on task	85.3	86.6
274 ... CP140 is en route to Contact 4	161.9	152.5
282 ... the expected location for contact is searched	55.0	52.4
294 ... updated surface plot is requested	65.8	63.0
296 ... investigation of Contact 2	277.8	285.6
340 ... Mini UAV prepared for release over Contact 4	31.8	34.4
374 ... Contact 2 located on the VTUAV radar	346.2	345.9
376 ... VTUAV route initiated and flown ***	100.9	42.9
386 ... Contact 2 is identified using the VTUAV EO ***	75.6	15.0

Table 3 Part 1 – Goal Mean Completion Time Summary

Goal	Goal Mean Completion Time (Sec) IAI OFF	Goal Mean Completion Time (Sec) IAI ON
400 ... the target of opportunity is investigated ***	85.2	47.3
416 ... surface plot updated using the CP140 radar	166.7	164.3
452 ... VTUAV tracking towards the waypoint	75.4	64.1
456 ... terrorist mission planning with the ROC	91.2	92.4
470 ... VTUAV route initiated and flown	13.0	12.0
486 ... VTUAV refuelling is planned ***	32.7	16.5

*** Note: Upper Level Goals which contain IAI tasks. All other goals are not influence by the IAI modes. See section 3.4.4

Table 4 Part 2 – Goal Mean Completion Time Summary

Goal	Goal Mean Completion Time (Sec) IAI OFF	Goal Mean Completion Time (Sec) IAI ON
120 ... VTUAV 1 employment has been planned ***	93.9	41.2
134 ... CP140 is level at 4000 ft en route Contact 4	541.0	541.0
136 ... MALE UAV has been tasked to investigate Contact 3	81.1	51.3
170 ... UAV Op and Plt intend to investigate Boat 1	30.1	27.1
180 ... the MALE UAV will conduct ISAR imaging of Boat 3	347.0	347.1
194 ... VTUAV 1 is cautiously approaching Boat 1	57.5	43.4

Table 4 Part 2 – Goal Mean Completion Time Summary

Goal	Goal Mean Completion Time (Sec) IAI OFF	Goal Mean Completion Time (Sec) IAI ON
206 ... plan for investigation of Contact 4 using a Mini UAV ***	103.4	66.7
260 ... CP140 on final run-in for deployment of MiniUAV1	190.3	150.4
292 ... VTUAV 1 has commenced EO Rig of Boat 1	307.4	308.3
330 ... MiniUAV1 is deployed ***	40.5	39.4
360 ... Boat 1 is classified ***	85.2	47.7
374 ... MALE UAV ISAR imagery of Boat 3 is analysed	91.1	36.6
410 ... the CP140 is turning south to Contact 5	70.8	35.1
416 ... Mini UAV is investigating Contact 4 ***	343.0	325.1
428 ... Boat 1 is identified and determined to be neutral ***	226.9	146.0
447 ... investigation of Cont. 4 by MiniUAV1 has commenced ***	49.1	14.2
475 ... plan for approaching Boat 2 is complete	83.4	76.0
500 ... identity Contact 4 is determined using Mini UAV1 ***	205.0	205.1
535 ... illegal fishing activities of Contact 4 are reported ***	132.1	126.0
546 ... Boat 3 is classified using the ISAR imagery from MALE UAV	17.8	18.0
564 ... MALE UAV is tasked to conduct ISAR imaging of Cont. 3	60.6	68.4
575 ... activity of known contacts in the area	33.6	30.9
600 ... message regarding the location of the operation area for VTUAV 2	44.4	27.8
606 ... Contact 3 is classified and determined to be neutral	42.9	42.0

Table 4 Part 2 – Goal Mean Completion Time Summary

Goal	Goal Mean Completion Time (Sec) IAI OFF	Goal Mean Completion Time (Sec) IAI ON
630 ... MALE UAV is tasked to conduct ISAR imaging of Boat 2	93.9	41.2
640 ... VTUAV 1 is approaching Boat 2 and preparing for EO Rig of boat	541.0	541.0
660 ... wide search for possible terrorist vessel is initiated	81.1	51.3

*** Note: Upper Level Goals which contain IAI tasks. All other goals are not influence by the IAI modes. See section 3.4.4

Table 5 Part 3 – Goal Mean Completion Time Summary

Goal	Goal Mean Completion Time (Sec) IAI OFF	Goal Mean Completion Time (Sec) IAI ON
120 ... plan to utilize available assets is developed	95.8	97.5
130 ... CP140 is in level flight en route Boat 2	194.2	189.5
132 ... VTUAV 1 is approaching Boat 2	80.2	80.0
148 ... ISAR imagery of Boat 2 is analysed	147.2	149.3
164 ... operational viability of VTUAV 1	51.6	48.3
180 ... SITREPs are being sent	33.2	35.3
192 ... decision is made that the CP140 should be the SAC	40.1	43.5
203 ... message from MOC regarding CF188 tasking	282.0	282.0
207 ... message from CPF regarding VTUAV 2 handover	14.7	14.4

Table 5 Part 3 – Goal Mean Completion Time Summary

Goal	Goal Mean Completion Time (Sec) IAI OFF	Goal Mean Completion Time (Sec) IAI ON
220 ... Mini UAV1 is terminated	3.2	3.2
230 ... the crew is briefed on the response to lost of VTUAV 1 ***	92.8	64.7
244 ... new ISAR imagery of Boat 2 is downloaded and studied	70.3	67.6
260 ... CP140 is approaching Boat 2	107.3	98.5
265 ... handover of VTUAV 2 is completed ***	496.1	469.1
278 ... Mini UAVs 2 to 5 are readied for launch ***	52.3	31.1
315 ... deployment of Mini UAVs 2 to 4 ***	65.8	8.1
325 ... CP140 is approaching release point for Mini UAV 5	102.7	96.4
335 ... Mini UAVs 2 to 4 are serviceable	64.0	57.3
355 ... deployment of Mini UAV 5	28.5	27.5
366 ... CP140 is proceeding to holding waypoint	122.0	140.8
368 ... message to direct CF188s to stand-by	27.3	19.9
375 ... activities on the deck on the boat which may allow classification of boat	109.7	107.2
385 ... Mini UAV 5 is employed over the downed VTUAV 1 ***	683.6	632.9
410 ... classification of the terrorist vessel is completed	51.0	51.8
427 ... decision to attack the terrorist boat has been made	25.2	25.1
438 ... CF188 attack has been authorized	15.1	15.3
444 ... CP140 crew have initiated activities to deploy Laser Mini UAV	13.4	13.5

Table 5 Part 3 – Goal Mean Completion Time Summary

Goal	Goal Mean Completion Time (Sec) IAI OFF	Goal Mean Completion Time (Sec) IAI ON
456 ... MALE UAV will be kept clear of CF188s	16.4	16.4
460 ... CP140 response to possible Lethal UAV launch is planned	442.0	420.8
470 ... Laser UAV is deployed from CP140 over terrorist boat	204.7	219.8
490 ... launch of Lethal UAV noted and initial response completed	51.4	53.3
510 ... control of the Laser UAV is established ***	143.2	120.7
524 ... VTUAV 2 will remain clear of CF188 attack	207.5	181.5
526 ... reassessment of need to attack terrorists is completed ***	82.3	60.2
550 ... directing, authorizing and authenticating of the CF188 attack is completed	81.7	81.5
556 ... search for the Lethal UAV is discussed and search plan initiated ***	53.3	27.6
560 ... utilization of Mini UAV during CF188 attack is coordinated	158.7	159.6
574 ... all UAVs are set to autonomous mode to allow CP140 to commence search ***	58.7	33.9

*** Note: Upper Level Goals which contain IAI tasks. All other goals are not influence by the IAI modes. See section 3.4.4

SECTION FOUR – CONCLUSIONS

4.1 GENERAL CONCLUSIONS

CMC collected data on the execution times of each upper level goal and used additional IP/PCT output to evaluate an operator's performance with and without IAI. The results of the simulation indicated that the UAV tactical crew maintained a consistently high intensity of activities throughout the various levels of increasing workload (increasing number of UAVs to control) and role complexity (UAV Pilot, UAV Operator, TACNAV). This was anticipated considering that the network assumes trained operators who operate at a steady and consistent level. This difference between mission activities with automation (IAI ON) and without is reflected in the time to complete critical task sequences. With goals that required planning the UAV flight paths or search patterns, reduced times were found using the IAI to assist the operator. The automation was evidenced through the interface anticipating the users' activities in high-workload situations and offering pre-calculated routes for the operator to accept or modify.

All goals that required intense verbal communications within the crew were also assisted using the IAI mode. Intelligent agents were modelled to anticipate the communication requirements and facilitate internal taskings and information transfer using an "intelligent communications agent". This agent proposed messages at opportune times and, without auditory distraction, passed the internal communication to the appropriate individual(s). Similarly, non-distracting feedback that the message had been received was modelled.

It was concluded that for some of the upper-level goals, time to achieve the goal was calculated by the model to be reduced by more than 50% when the IAI mode of operation was selected. It was also concluded that the operational control of UAVs from an airborne platform was a complex task and workload increased during use of multiple disparate UAV assets. The composite scenario that was produce contained three levels of workload for each of three operators whose respective roles represented three levels of complexity. The use of a workstation that incorporates an IAI mode permitted operators to continue working with a high intensity and resulted in upper-level goals being achieved in reduced time.

Other conclusions were that:

a. the HGA for the one-hour scenario involving 3 UAV crewmembers in the CP140 was initially incomplete when the goals were only identified using a "top-down" approach. Once OSDs were produced, the list of operator goals were expanded significantly (by approximately 20%);

b. the results shown in Table 3 through Table 5 show that, as expected from the preliminary analyses, the greatest advantage of the IAI mode of operations appears to be a reduction in the time required to complete upper level goals. This is complimented by modest reductions in the Task Conflict Parameter (Subsection 3.4.2) and the reduction in the number of tasks interrupted, delayed or shed (Subsection 3.4.3);

c. the use of an intelligent communication agent should be considered as one of the UAV IAI functions of a future CP140 tactical compartment workstation; and

d. the use of an intelligent route planner should be considered as another one of the UAV IAI functions of a future CP140 tactical compartment workstation.

SECTION FIVE – RECOMMENDATIONS

5.1 GENERAL RECOMMENDATIONS

The conclusion of this report indicates that there is a real potential for improvement in the effectiveness of military operators when working with complex systems that incorporate an IAI mode of operation. The network analysis conducted using the IP/PCT mode IPME provided numerical evidence of improved performance. As a result, and given the potential advantages of using IAI in cognitively complex interactions with advanced systems, it is recommended that further research be undertaken to more fully explore and document the advantages of IAIs. Furthermore, it is recommended that the scenario used for this analysis be the basis for further research.

There were areas that would benefit from further study. These areas involve the specifics of applying IAI to the future CP140 workstations. The tasks that were identified as IAI tasks in this study could only be considered a "first cut" at the tasks that would be most important candidates for augmentation with an IAI mode. Further analysis regarding the most beneficial tasks to modify is recommended. Additionally, it is important to focus on an experimental design necessary to test the efficacy of IAI in future studies. Considerable effort may be required to implement an IAI into future systems, and strong and reportable evidence would be important to substantiate this effort.

ANNEX A

ACRONYMS AND ABBREVIATIONS

ANNEX A – ACRONYMS AND ABBREVIATIONS

ALIX	Atlantic Littoral Intelligence, Surveillance and Reconnaissance Experiment
AOO	Area of Operations
CCG	Canadian Coast Guard
CF	Canadian Forces
CFEC	Canadian Forces Experimentation Centre
CHOGM	Commonwealth Heads of Government Meeting
CMC	CMC Electronics Inc.
CPF	Canadian Patrol Frigate
DFO	Department of Fisheries and Oceans
DND	Department of National Defence
DRDC	Defence Research & Development Canada
GUI	Graphical User Interface
HCI	Human Computer Interface
HFE	Human Factors Engineering
HGA	Hierarchical Goal Analysis
IAI	Intelligent/Adaptive Interfaces
IISR	Integrated Intelligence, Surveillance, and Reconnaissance
IP	Information Processing
IP/PCT	Information Processing/Perceptual Control Theory
IPME	Integrated Performance and Modelling Environment
ISAR	Inverse Synthetic Aperture Radar
ISR	Intelligence, Surveillance and Reconnaissance
MALE	Medium Altitude Long Endurance
MOC	Maritime Operations Center
MOE	Measure of Effectiveness
MOP	Measure of Performance
OGD	Other Government Departments
OMI	Operator Machine Interface
OSD	Operational Sequence Diagrams
OTH	Over The Horizon
PCT	Perceptual Control Theory
PLIX	Pacific Littoral Intelligence, Surveillance and Reconnaissance Experiment

POP	Prediction of Operator Performance
R&D	Research and Development
ROC	Regional Operations Center
SA	Scientific Authority
SME	Subject Matter Experts
TACNAV	Tactical Navigator
UAV	Uninhabited Air Vehicles
UAV Op	UAV Operator
UAV Plt	UAV Pilot
UCAV	Uninhabited Combat Air Vehicles
UK	United Kingdom
USAF	United States Air Force
USN	United States Navy
VTUAV	Vertical Take-off UAV

ANNEX B

MISSION SCENARIO

ANNEX B – MISSION SCENARIO

B.1.0 INTRODUCTION

The mission scenario described in this annex forms the basis for an analysis of CP140 Unmanned Air Vehicle (**UAV**) crewmember activities (goals and task interaction) This mission is set seven years in the future.

The scenario begins with a fictitious advanced briefing to Commonwealth Heads of Government Meeting (**CHOGM**) security staff, conducted in February 2011. Following this, a description of the situation on the day of the opening of the CHOGM is provided, as well as a brief overview of the one-hour scenario. A detailed description of the scenario follows, along with illustrative figures contained within the text.

B.1.1 COMMAND AND CONTROL OF CP-140 UAV TEAM

The CP140 is manned by a crew, which is augmented by two additional crewmembers who have responsibility for controlling UAV assets. These are the UAV Operator (**UAV Op**) and the UAV Pilot (**UAV Plt**). It is possible that these individuals may be CP140 crewmembers who have been cross-trained to operate the Canadian Forces (**CF**) UAV fleet. The CP140 in under the control of the Military Operations Centre in Halifax and the Medium Altitude Long Endurance (**MALE**) UAV is under the control the Regional Operations Centre (**ROC**), which is, for the purposes of this scenario, also located in Halifax. The CP140 tactical crew consists of the Tactical Navigator (**TACNAV**), or mission commander, the UAV Operator and the UAV Pilot. The TACNAV occupies his or her normal position, and to the left of the TACNAV are the UAV Operator and Pilot. These two individuals occupy the Acoustic Sensor Operator (**ASO**) reconfigurable workstations of the modernized CP140. The TACNAV has overall responsibility for the UAV mission, the UAV Operator is responsible for ensuring that the data and images are collected effectively and controlled for use in civilian court, and the UAV Pilot (who has the least complex role) is responsible for UAV flight path and air vehicle systems.

COMMONWEALTH HEADS OF GOVERNMENT MEETING (CHOGM) SECURITY NOTES - 5 FEBRUARY 2011

B.2.0 ADVANCE BRIEFING ON CHOGM SECURITY (BY RCMP HEAD OF SECURITY)

Today I will brief 80 officials of 29 Commonwealth countries regarding Canada's security preparations for the forthcoming Commonwealth Heads of Government Meeting on Canada's Eastern Coast from 2-5 March 2011.

The advance visit is an integral element of the overall commitment to planning for CHOGM 2011, and will provide vital information on administrative and security arrangements to countries attending the meeting. It is an important occasion at which foreign officials will be briefed on CHOGM preparations and have the opportunity to inspect CHOGM venues and hotels.

We have planned the security arrangements to ensure that the CHOGM runs smoothly and safely, ensuring its success. There is no known specific threat of terrorism against CHOGM 2011. However, following the uncovering of terrorist attacks planned against the Olympic Winter Games on January 11, 2010, the security arrangements for CHOGM 2011 have been reviewed and upgraded.

As a result of the changed security environment, CHOGM is now a smaller, more streamlined event, and has been moved to St. John’s, Newfoundland. A comprehensive and robust range of security measures is being implemented to ensure the safety of the participants.

The responsibility for CHOGM security and the protection of dignitaries, their spouses and officials rests with both the Canadian Federal Government and the Newfoundland and Labrador Provincial Government. We are coordinating our planning and operational arrangements.

I will stress to officials that Canadian agencies take full responsibility for the protection and safety of foreign dignitaries visiting our country. Foreign security officials have no operational role in Canada and they are neither authorized nor permitted to carry weapons of any type.

Everyone wants CHOGM to be incident free and successful, delivering real outcomes for the people of the Commonwealth of Nations.

Our preparations, planning and practices have been first rate, and I am confident that Canada will provide the best possible arrangements and security for the attending dignitaries.

B.3.0 THE SITUATION

The year is 2011 and the Commonwealth of Nations has chosen St John's, Newfoundland, as the site for the bi-annual CHOGM. Both the Prime Minister of Canada and the Premier of Newfoundland and Labrador are enthusiastic about the session. The CF will provide security for the meeting, as they have at many international meetings. The CF are well prepared for the security aspects of this visit, having completed a flawless mission of providing security for the 2010 Olympic Winter Games in Vancouver. The British are assisting with intelligence services, and there is a British Manchester Class Type 42C destroyer tied up alongside the jetty in St. John's for a port visit. In addition, four CF188 Hornets are positioned at Gander, of which two are on alert. Four more CF188s are located at Canadian Forces Base (**CFB**) Greenwood, N.S., with two on alert.

The date is March 2, 2011, and the CHOGM will commence with a two-hour dinner scheduled to begin at 21:30 hrs. All Heads of State will be in attendance.

A MALE UAV is supporting CHOGM security with over-flights that produce photographs that are compared to monitor changes in the vicinity. By this method, the only items highlighted are those that differ from one point in time to another point in time. Thus, the MALE UAV operators can identify structures such as lookout or shooting position blinds. Additionally, these operators can search for vehicles that have been left unattended for extended periods in tactically sensitive areas.

At 17:30 hrs, the RCMP, based on a MALE UAV intelligence report, investigate a suspicious house in Quidi Vidi Village, and find inconclusive details regarding a plan to undertake laser targeting in the city that evening. The MALE UAV operators monitor a van, which is observed at the house in question and at numerous locations that provide exceptional sight lines to CHOGM sensitive locations. Defence Terrain Elevation Data (**DTED**) Level 2, 3-dimensional (**3-D**) mapping was used during initial site assessments by the Royal Canadian Mounted Police (**RCMP**) to determine the viewing locations of concern. Immediately, a warning is broadcasted, and all military, paramilitary and civilian forces in the area are placed on a heightened state of alert.

At 17:45 hrs, British Intelligence relays information about a Lethal Medium Range UAV (poor man's cruise missile), which uses the same targeting laser frequencies as those found at the Quidi Vidi Village location. This device is similar to the German KZO or Muche, which is launched from within a van-sized steel container. The intelligence groups suspect that the Lethal UAV will be launched from a boat that may be as far as 240 nm away. The Lethal UAV of concern will be flying too slow to be identified by NORAD radars, and the UAV will be too small to be found using the High Frequency (**HF**) Surface Wave Radar at Cape Race. An addendum to the Lethal UAV warning made reference to recent reports that the group suspected of fielding the weapon had obtained a quantity of plutonium from a nuclear power plant located in the Middle East. A UAV carrying a plutonium "dirty bomb" would cause many casualties and render the targeted region inaccessible for years.

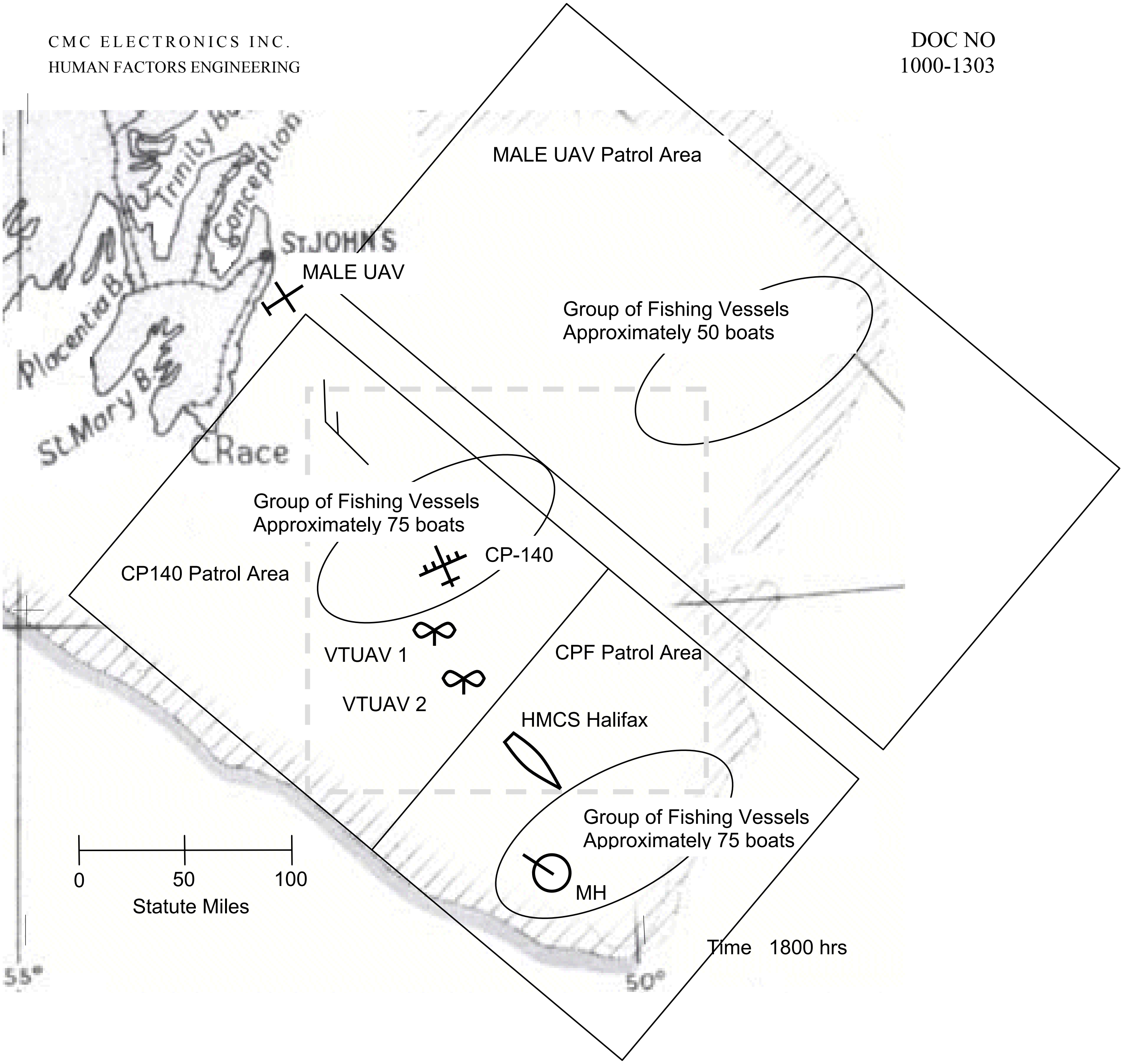


Figure B-1 Grand Banks Overview at 18:00 Hrs

There is an ongoing fisheries patrol southeast of St. John's, and approximately 200 vessels have been plotted in the vicinity of the nose and tail of the Grand Banks. HMCS Halifax is on-scene with two Vertical Take-Off UAVs (**VTUAV**) and a Maritime Helicopter (**MH**); one CP140 Aurora patrol aircraft equipped with 16 Mini UAVs and its own sensor suite is overhead. The CP140 initiates its patrol with a surface plot downloaded from the Cape Race HF Surface Wave Radar.

A Priority message is broadcasted simultaneously to all military assets in the vicinity. A database search is conducted to find unknown or new vessels in the area. Eight contacts are determined to be suspicious. A review of the National Architecture eliminates three of these vessels (recent updates to the database were applied). Of the five remaining contacts, four are in the vicinity of the Aurora. Just prior to 18:00 hrs, HMCS Halifax passes control of one of its airborne VTUAVs to the Aurora crew, because the suspicious contacts were greater than 100 nm from the ship and direct control could not be maintained over the VTUAV at that distance. Another contributing factor in the limited operating range of the VTUAV is that the ceiling is at 1000 ft. At the same time that the Priority message is broadcasted, the MALE UAV is re-tasked to assist with the search for the threat vessel. Through coordination with the Maritime Operations Center (MOC) in Halifax, Nova Scotia, the CP140 fisheries patrol area is subdivided into East and West sectors, and the MALE UAV is assigned to the East sector. The MALE UAV, operated by a crew in the Halifax Regional Operations Centre (ROC), prosecutes the fifth contact, which is further east. In order to ensure separation, the MALE UAV is assigned airspace 7000 ft and above; the CP140 is assigned 6000 ft and below.

The weather in the operating area is overcast, 1000 ft ceilings, wind 15 kts from the northwest, temperature 10° C with a 5° C dew point spread, and the seas are Sea State Three, with a swell approaching from the southwest. The low ceilings and moderate sea state limit the Electro-Operatortic (**EO**) viewing range from the CP140 and UAVs to 5 nm or less.

Figure B-1, Figure B-2 and Figure B-3 illustrate the situation off the southeast coast of Cape Race at 18:00 hrs.

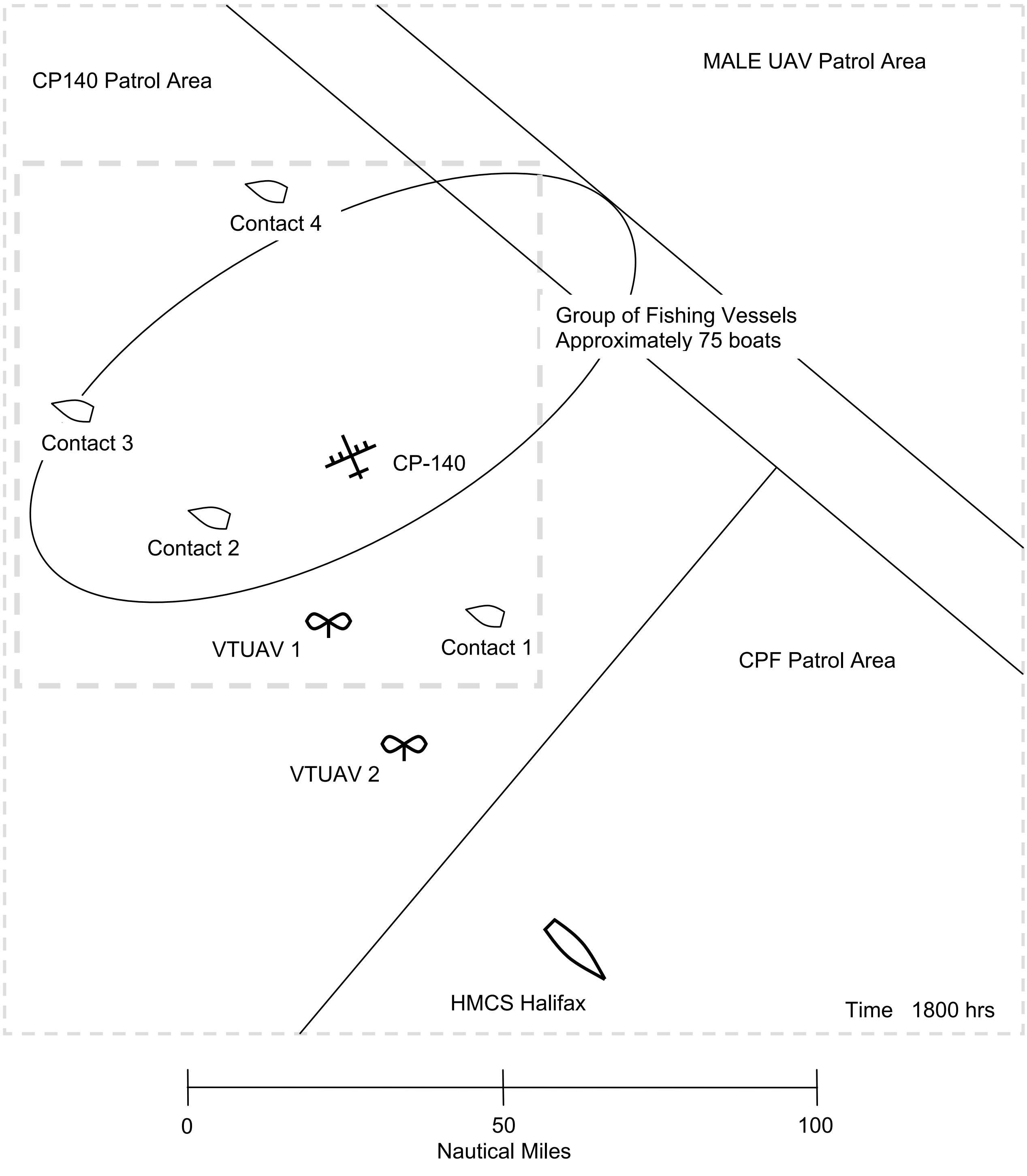


Figure B-2 Overview of CP140 Operating Area

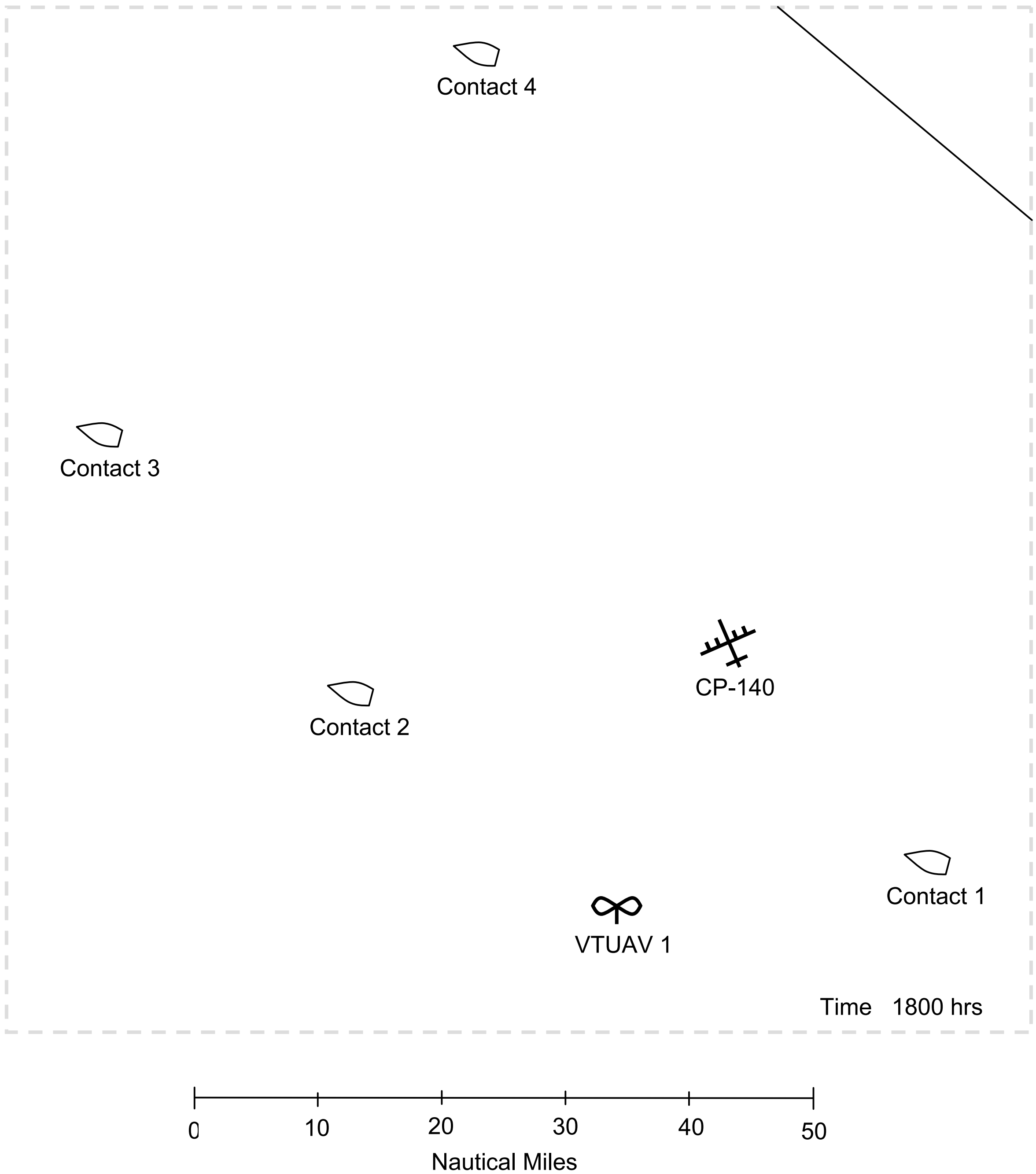


Figure B-3 Contacts in the Vicinity of the CP140 at 18:00 Hrs

B.4.0 A BRIEF OVERVIEW OF THE SCENARIO

For the purpose of this scenario, the UAVs are controlled from the CP140 Acoustic Sensor Operator (ASO) positions, and the UAV crew consists of the TACNAV, the UAV Operator occupying the ASO 1 position and a UAV Pilot occupying the ASO 2 position (the aisle seat). The rest of the CP140 crew supports the mission.

The scenario begins at 18:00 hrs, after the Aurora crew has received information that a terrorist threat to the CHOGM is possible and they are re-tasked to search for a vessel that is carrying a container the size of the KZO launch container (approximately 10 ft x 8 ft x 20 ft). Reports have suggested that the threat may come from a trawler-sized vessel.

The vast majority of the fishing fleet is operating under overcast conditions, approximately 100 nm offshore. Visual identification will require flight below the cloud ceiling. Two of the Canadian Patrol Frigate (**CPF**) VTUAVs are airborne and HMCS Halifax has just handed off control of one of these assets (VTUAV 1) to the CP140 flight crew to assist in contact identification.

Two CF188s are scrambled and tasked to proceed to an area 20 nm south of St. John's and mount a combat air patrol.

Once the VTUAVs clear their mother ship, HMCS Halifax makes ready and launches the new MH. The mission is to investigate another concentration of vessels to the south. The ship's crew knows that recovery of VTUAV 1 will be necessary at approximately the same time that the MH returns, but the situation dictates that all three vehicles be airborne. Modification of the flight deck to accommodate the recovery of the MH and VTUAVs is the latest alteration to the vessel.

At approximately 18:40 hrs, contact is lost with VTUAV 1 as it approaches a vessel under investigation. The Aurora immediately launches three Mini UAVs and warns other airborne units to avoid the possible threat. The MALE UAV (using Inverse Synthetic Aperture Radar [**ISAR**] from medium altitude) and the Mini UAVs investigate the vessel, and at the same time HMCS Halifax makes best possible speed to the same location. VTUAV 2 is also directed towards the suspicious boat and control is passed to the CP140 crew.

At approximately 18:50 hrs, a Mini UAV transmits an image of men working on the foc'sle of the trawler. These individuals have exposed a large storage container. The CP140 continues to covertly observe through the EO sensor of VTUAV 2 and Mini UAVs as the container is opened to expose a Jet Assist Take-Off (**JATO**) UAV. The CF188s are ordered to attack the now identified terrorist boat. Minutes later, the Lethal UAV is launched. Communicating with the MALE UAV operator via a chat room, the crew provides the departure heading of the Lethal UAV and the MALE UAV operator initiates tracking. Observation of a second Lethal UAV on the terrorist boat heightens concern until a successful fighter attack is carried out.

At 19:00 hrs, the scenario ends, although the mission is still ongoing. The Aurora crew initiate a search for the Lethal UAV, which is tracking randomly towards St John's.

B.5.0 DETAILED SCENARIO DESCRIPTION – PART 1

Table B-1 Scenario Description – Part 1

Timeline	Event
18:00 hrs	The Aurora UAV crew is occupied with controlling VTUAV 1, which is investigating two contacts (Contacts 2 and 3); at the same time, the aircraft is transiting to observe two different fishing vessels (Contacts 1 and 4). Initial one-to-one data link control with VTUAV 1 was established prior to 18:00 hrs. The CP140 is level at 4000 ft.
18:01 hrs	The UAV operator re-familiarizes himself with the systems onboard VTUAV 1, including settings established by the CPF UAV crew. As a test of the system, he initiates an observation of a known contact in the direction of flight. The crew's third pilot occupies the vacated ASO 2 position and reconfigures this workstation to a STANAG 4586 configuration for flight control of the CPF's VTUAV.
18:02 hrs	The TACNAV plans the route for the Aurora, and requests that the pilots descend below the cloud, and turn and head towards the first contact at high speed. Non-Acoustic Sensor operator (**NASO**) 1 generates a GENTRACK on the target and directs the pilots for a homing from the stern until the EO operator gains contact. The flight crew work with the NASO 1 (AESO 1) who is using the onboard radar to clear the way ahead for the descent and at the same time search for the contact of interest. The NASO 2 configures the EO to begin a Charge Coupled Device (**CCD**) colour camera and an Infrared (**IR**) sensor search to classify and potentially identify the unknown contact once the aircraft descends below the cloud.
18:03 hrs	The NAVCOM completes his radio transmission, acknowledging the current tasking with MOC in Halifax.
18:04 hrs	The TACNAV and UAV operators work as a team to plan the route and search activities of VTUAV 1. The UAV operator is occupying the ASO 1 position and has configured the workstation to a STANAG 4586 standard for control of imagery. The TACNAV requests that the UAV Pilot direct VTUAV 1 to an initial heading of 300° true, maintain 800 ft Above Sea Level (**ASL**), and increase speed to the dash speed of 200 kts. The UAV Operator uses the Telephonics 1700B (Mark II) Radar to search for Contact 2. The TACNAV extrapolates the last known position, course (315° true) and speed to establish a datum. Most of the fishing vessels in the area are headed northwest into the wind with their nets deployed.
18:05 hrs	NASO 1 is fully occupied with updating the radar plot. At 15 nm from Contact 1, the Aircraft Captain (**AC**) reports that the aircraft is level at 800 ft.

Timeline	Event
18:06 hrs	The NAVCOM obtains additional information regarding the type of contact and potential threat the crew may encounter, updates the Electronic Support Measures (**ESM**) library and presets for chaff and flares.
18:07 hrs	The UAV Pilot begins to take stock of the fuel onboard VTUAV 1, potential landing pads (CPF, Hibernia oil drilling platforms, etc.), and refuelling locations. The pilot advises that the UAV will have at least two hours on-task and that a more refined time estimate will be available soon.
18:08 hrs	The EO Operator establishes contact with the first vessel to be investigated (Contact 1) and the flight crew plans an EO rig, which will allow effective observation and at the same time minimize the threat from surface to air missiles. The UAV Pilot and the TACNAV conclude that VTUAV 1 must eventually return to the CPF because there is no other suitable landing area in the vicinity.
18:09 hrs	The name and licence of Contact 1 are determined.
18:10 hrs	The flight crew reach the closest point of prudent approach and commence an arc around Contact 1. Using the name and licence of Contact 1, the NAVCOM accesses the Department of Fisheries and Oceans (**DFO**) online database for the East Coast to get a confirmation photo and history of this boat.
18:11 hrs	As the CP140 circles Contact 1, NASO 2 continues to observe the boat using the EO suite.
18:12 hrs	The UAV Operator and TACNAV continue tracking VTUAV 1 towards Contact 2. While generally following the route to the datum, the course of VTUAV 1 is varied twice to allow for identification of two contacts near the route. NASO 2 reports that the nets on Contact 1 are just about to be streamed, and a large box-shaped object on the foc'sle is a large pile of crab traps. The TACNAV directs the crew to proceed to Contact 4. With a transit speed of 240 kts, the 62 nm distance is covered in approximately 16 minutes.

Timeline	Event
18:13 hrs	MOC advises the Aurora crew that the MALE UAV is able to assist in approximately 8 minutes. The crew is directed to contact the ROC. The Raytheon Sea Vue (Mark II) Radar of the MALE UAV is out of range. The UAV Operator asks Ordinance to prepare one Mini UAV for deployment. The TACNAV sets the operating height electronically for 1000 ft so that the tactical crew could deploy the Mini UAV from altitude and with minimum time delay to obtain video imagery from below the clouds. The Mini UAV is prepared in anticipation of deployment over Contact 4. The AC advises that Contact 1 has been identified as the Guppy from Portland, Maine, and he is turning the aircraft toward Contact 4. The TACNAV requests that the Aurora Pilot climb to 4000 ft in order to maintain the data link with VTUAV 1.
18:14 hrs	The NAVCOM confirms that the Guppy is not on any of the Vessel of Interest lists.
18:15 hrs	The CP140 continues towards Contact 4. The pilot reports that the aircraft is level at 4000 ft.
18:16 hrs	NASO 1 uses the ISAR to scrutinize Contact 2. It is determined that although the length and breadth of Contact 2 match the search criteria, there is nothing unusual about the structure and this Contact is unlikely to be the terrorist vessel. Regardless, the decision is made to identify Contact 2 using VTUAV 1. VTUAV 1 changes course slightly to investigate Contact 2.
18:17 hrs	The NAVCOM requests an update on the air picture from the Halifax. Contact 2 is identified as the Dolphin from Miami, Florida. It is fishing legally. VTUAV 1 turns towards Contact 3 and level flight at 800 ft is maintained. With a momentary lull in the action as both the CP140 and VTUAV are in transit, the TACNAV initiates a discussion with the AC to try and determine the location of the terrorist vessel. It is deemed that a terrorist vessel would have turned towards St. John's, the site of the CHOGM. At the same time, MOC asks the CP140 to also investigate a suspicious boat 20 nm north of VTUAV 1. MOC recommends caution when approaching this boat. A datum for Contact 5 is plotted on the computer.
18:18 hrs	As VTUAV 1 is already closer to the new target vessel, the TACNAV directs the UAV Pilot to investigate Contact 5 before Contact 3, once investigation of Contact 2 is complete.

Timeline	Event
18:19 hrs	VTUAV 1 has completed investigation of Contact 2 and turns towards Contact 5. The VTUAV 1 time on-task is approximately 2 hours and 10 minutes; it must return to the CPF. Coordination will be required because that will be the approximate time that the MH will require refuelling. The deck cycle has been interrupted due to the urgent nature of the mission. The remaining VTUAV 2 time on-task is lengthy considering the recent launch, and will not require refuelling for many hours.

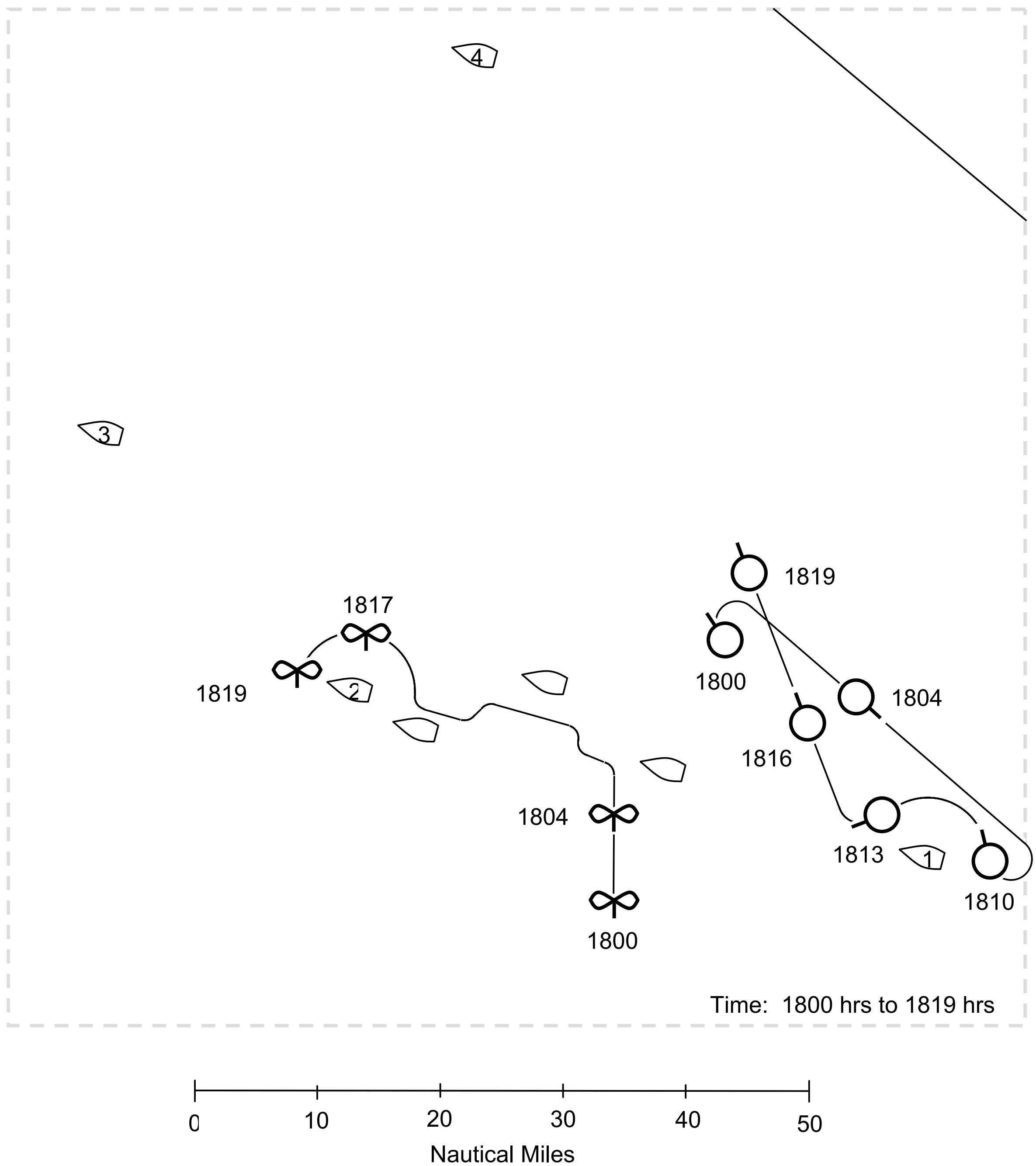


Figure B-4 Detailed Mission Scenario – Part 1

B.6.0 DETAILED SCENARIO DESCRIPTION – PART 2

Table B-2 Scenario Description – Part 2

Timeline	Event
18:20 hrs	The UAV Operator begins to create a surface plot of the area around the datum as VTUAV 1 transits towards the new search area. The Aurora continues towards Contact 4 at 4000 ft. ROC advises the NAVCOM that the MALE UAV has completed the search in his area and is standing by to assist the CP140 on the eastern boundary of the Aurora's area.
18:21 hrs	The TACNAV requests that the MALE UAV enter the CP140 area, but remain at 7000 ft or above, whereas the CP140 will remain at 6000 ft or below. The MALE UAV is to investigate Contact 3.
18:22 hrs	With the combined Radar data from VTUAV 1 and the Aurora, the TACNAV quickly builds a plot of contacts in the area of Contact 5 and selects three vessels of which one could be the terrorist boat. The TACNAV directs VTUAV 1 to investigate the first of the three boats and requests that the MALE UAV use its ISAR radar to image the second of the three boats while heading to Contact 3.
18:23 hrs	The TACNAV then directs his attention towards Contact 4.
18:24 hrs	NASO 1 has a good GENTRACK on Contact 4 and directs the pilot for the homing down the Mean Line of Advance (**MLA**).
18:25 hrs	The UAV Pilot turns VTUAV 1 towards the first boat (designated Contact 5) and then concentrates on establishing a waypoint near this boat, which will allow a discreet approach. The pilot is aware that the VTUAV is relatively noisy and an approach from east-southeast will keep the vehicle downwind. He also considers that the overcast conditions will give no advantage to approaching with the sun behind the vehicle. The UAV Pilot decides that a waypoint on a relative bearing of 120° true at 5 nm from the contact is best, although this requires a diversion from the direct route and a 90 left turn to approach the boat. The UAV Pilot notes that the boat is heading west-northwest like the other fishing vessels. The UAV Pilot established a transit speed of 120 kts.
18:26 hrs	The TACNAV presets the waypoints and search pattern for the Mini-UAV (automatic actions to be taken after launch if the UAV Pilot cannot gain control of the vehicle).
18:27 hrs	The UAV Pilot brings VTUAV 1 as high as possible without entering the clouds.
18:28 hrs	After reviewing the Contact history (from the original portion of the fisheries patrol), the TACNAV advises the UAV Pilot and UAV Operator that one of the three boats in that group should be the fishing boat "Trust Me".

Timeline	Event
18:29 hrs	The AC tells the TACNAV that the aircraft is two minutes back from Contact 4 and he is slowing the aircraft down to a speed that will allow deployment of a Mini UAV. Using the estimates of the wind generated by the Embedded Global Positioning Systems/Inertial Navigation Systems (**EGIs**), the TACNAV makes a final determination of the Pickle Point and passes this to the pilot.
18:30 hrs	The ROC advises that the ISAR imagery of the second boat should be available in two minutes.
18:31 hrs	The flight deck crewmembers review the online checklist for Airborne Mini UAV Deployment.
18:32 hrs	The UAV Operator reports to the TACNAV and UAV Pilot that he has verified the identity of the "Trust Me" from Come-By-Chance, Newfoundland, and recommends that the pilot resume course to the third boat suspected to be Contact 5. The UAV Pilot provides VTUAV 1 with commands to head towards a waypoint established at 5 nm from the unknown boat. The UAV Pilot verifies that VTUAV 1 is operating within normal parameters and prepares to take control of the Mini UAV once it has dropped to 1000 ft, is deployed from the A-size parachute stabilized container, and is established in straight and level flight. The initial heading will be into the wind, as pre-programmed prior to deployment. NASO 2 accesses the ROC image server, extracts the MALE UAV ISAR image and compares it to the last VTUAV contact. He advises the TACNAV that both the MALE UAV and VTUAV 1 have investigated the same boat. The NAVCOM advises the ROC of the mix-up and requests imaging of the second boat.
18:33 hrs	Upon reaching the UAV Fly-to-Point, the CP140 automatically releases the Mini UAV. The AC verbally advises that the Mini UAV has been deployed over Contact 4, and both the TACNAV and UAV Pilot verify this with their display symbology. The Aurora is turned towards the area of Contact 5 to assist with finding this boat. The crew track the descent of the Mini UAV over Contact 4 and wait for an uplink of a video image. On queue, at 1000 ft, the Mini UAV transmits that it has established level flight, into wind, and is standing by for control signals. The UAV Pilot takes control of the Mini UAV and verifies its serviceability.
18:34 hrs	The TACNAV directs the AC to maintain the current altitude (4000 ft). The UAV Pilot, with assistance from NASO 1, turns the Mini UAV in the direction of Contact 4 and, while accommodating for the wind, establishes a track directly towards the boat. He also initiates an enroute descent to 300 ft. At this time, he checks on the progress of VTUAV 1 and finds that the vehicle is proceeding as directed towards the waypoint. NASO 1 advises that the Mini UAV is within 2 nm of the contact, and at the same time, the UAV Operator advises that EO is active, although the boat is not in the Field-Of-View (**FOV**).

Timeline	Event
18:35 hrs	NASO 2 reports to the TACNAV that the MALE UAV imaging of the second boat in the vicinity of the new datum has been completed. Although the boat could not be identified, it was determined to be a small trawler and there did not appear to be any container shaped structure on the decks. The TACNAV rejects this boat as a possible terrorist threat and directs the MALE UAV to attempt imaging of the third boat. Having established that the Mini UAV deployed over Contact 4 is functioning nominally, the UAV Pilot passes control of the flight path to the UAV operator, but still maintains an overview of the UAV progress to assist if required. Manual flight control is a reversionary mode, however, the pilot would have to have been following the UAV activities in order to use this reversionary mode effectively, if it becomes necessary. The UAV Pilot also monitors the progress of VTUAV 1. The UAV Operator uses the point and click control features of the interface to establish a sea level waypoint at the location of Contact 4. The crew does not have to concern themselves with the data link because the Mini UAV transmits omni-directionally. With the UAV FOV presented on the UAV Operator's tactical plot (**tacplot**), the operator drags the FOV trapezoid over the radar contact and zooms in using the UAV's EO suite. The Mini UAV flies directly towards the unsuspecting fishers.
18:36 hrs	The UAV Operator records a high-quality video image of Contact 4. He uses the onboard database and support from the ROC database to determine that the boat is a known vessel, "Master", but is fishing illegally in a zone that does not open for another 5 hours and 27 minutes. The crew have just hauled in the nets and the rear deck is awash in fish. The TACNAV requests that NASO 1 update the position of Contact 3 and all three boats in the vicinity of Contact 5. The TACNAV then directs the NAVCOM to access the online "Fishing Violation" report and action it.
18:37 hrs	The Mini UAV over Contact 4 is set on autonomous Operations to report automatically all information required to prosecute the vessel "Master" in court. Video and location information is recorded onboard the Aurora. The Aurora crew direct their attention to the remaining unknown boat in the vicinity of the new datum, which is determined (by the process of elimination) to be Contact 5 and, thus, has a higher priority than the fishing violator.
18:38 hrs	The crew determine that with the approach path planned, VTUAV 1 will pass near a small fishing boat at approximately 2 miles from Contact 5. The crew decide that they will observe this boat enroute to their primary objective. The CPF advises that VTUAV 2 is investigating a small group of fishing vessels to the south of the VTUAV 1 position (which they know from the LINK-11 picture transmitted by the CP140). The MALE UAV completes imaging of Contact 3 and attempts to image Contact 5.

Timeline	Event
18:39 hrs	NASO 2 reports to the TACNAV that the ISAR imagery of Contact 3 from the MALE UAV shows that it is very similar to the previous boat studied and that there were no suspicious container shapes on the decks. The TACNAV decides that further investigation of Contact 3 is not necessary and turns to the surface plot to determine how to employ the MALE UAV. He begins to resize the area displayed on his workstation. The UAV Operator reviews the data being collected by the Mini UAV deployed earlier and finds that good video was collected up until the fishers spotted the Mini UAV and then covered the deck with a tarpaulin. The boat had turned south with the Mini UAV in a holding pattern approximately ½ nm aft. The NAVCOM reports the fishing violator to the DFO, and advises where video and location information can be found via a secure chat room. The UAV Pilot monitors the progress of VTUAV 1 as it flies towards the waypoint.

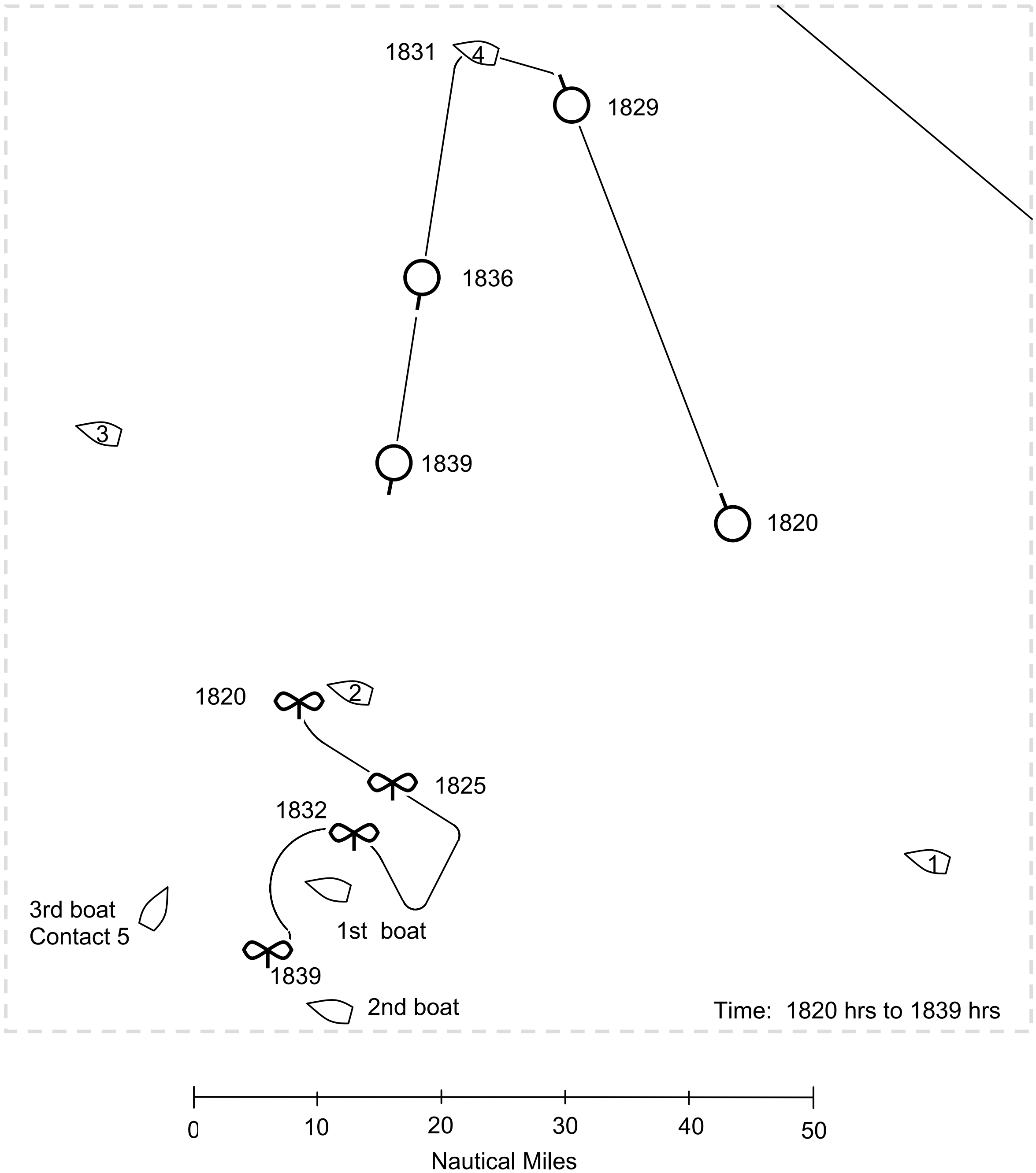


Figure B-5 Detailed Mission Scenario – Part 2

B.7.0 DETAILED SCENARIO DESCRIPTION – PART 3

Table B-3 Scenario Description – Part 3

Timeline	Event
18:40 hrs	VTUAV 1 reaches the waypoint and turns towards Contact 5. The EO sensor shows only the small fishing boat 3 miles from Contact 5.
18:41 hrs	At three miles from Contact 5, the VTUAV maintains 800 ft to observe the object of their search. The UAV Operator then swings the EO over to photograph the fishing boat they are passing. The fishers onboard are looking and pointing at the UAV. The ROC reports to the NAVCOM that the ISAR imagery from Contact 5 shows a very unusual structure on the bow of the vessel. Strong returns are obtained from large metal corners that are not common on the other fishing boats. The image of the small fishing boat is the last image recorded when the UAV Pilot reports that VTUAV 1 has stopped transmitting data. Moments later NASO 1 switches the radar to Air-to-Air and reports that radar contact with VTUAV 1 has been lost. 

Timeline	Event
18:42 hrs	The TACNAV contacts the ROC and requests that the MALE UAV keep imaging contact 5. The TACNAV quickly realizes that someone must take control of the situation, the Mini UAVs onboard the Aurora and VTUAV 2 are the only source of additional information. The MH has been vectored towards the scene, but will not arrive for at least 25 minutes. The crew assesses that they are the most capable platform on the scene at the current time. The CP140 assumes Shipborne Aircraft Controller (**SAC**) duties. The CPF advises that it can vector VTUAV 2 towards Contact 5 and complete a handover to the CP140. The VTUAV is 20 nm from Contact 5 and the CPF advises that the CP140 crew should take control of this asset in one minute. MOC also advises that the CF188s have been tasked to close at maximum speed. This section of hornets is to report momentarily on their weapons load and weapon of choice to render Contact 5 incapacitated on the designated frequency. The NAVCOM sets the appropriate radio. The CP140 crew is unclear as to why the VTUAV was lost. A review of the last frames of video does not help, because the small fishing boat the crew was observing at the time did not appear to take any overt action. The TACNAV determines that identification of Contact 5 must be performed as soon as possible to avoid sinking a potentially neutral boat. The TACNAV advises both the UAV Operator and the UAV Pilot to terminate the Mini UAV over Contact 4.
18:43 hrs	The TACNAV requests that the AC increase speed to Velocity Never To Exceed (**VNE**) or 'go Buster'. The current altitude (4000 ft) will keep the aircraft above cloud and hidden from EO/IR missiles. Transmissions are to be secure from this point on. Full Electronic Warfare (**EW**) policies are to be adhered to. The TACNAV briefs the crew that he intends to over fly the contact and deploy three Mini UAVs and then establish an orbit, which would maximize reception from the Mini UAVs. He requests that the NAVCOM transmit these intentions to the CF188s and the MOC. Preliminary imaging data are received from the MALE UAV, which show a medium sized fishing vessel with an unusual structure near the bow. The boat is maintaining a steady course north-northeast.

Timeline	Event
18:44 hrs	The pilot advises the crew that the aircraft is 2 minutes back. The crew takes control of VTUAV 2 and vectors it directly towards Contact 5, at an altitude of 2500 ft (above the clouds). Estimated Time of Arrival (**ETA**) at Contact 5 is 8 minutes. The TACNAV asks Ordnance to load three Mini UAVs, and set them to establish level flight at 1000 ft, 800 ft and 600 ft. He then asks the UAV Pilot to use the two lowest Mini UAVs to initiate cloverleaf patterns about the contact with a descent to 200 ft and 400 ft on each pass. The highest Mini UAV is to be used for a circular pattern about the contact at 800 ft. Wind and mutual separation must be accommodated, however, maximizing viewing time is essential. The UAV Operator advises that he will transmit all relevant photos and video images via the net chat room.
18:45 hrs	The UAV Pilot recommends to the TACNAV that a Mini UAV be deployed to investigate the site where contact was lost with VTUAV 1. The TACNAV concurs, puts a waypoint on the Electronic Horizontal Situation Indicator (**EHSI**) and requests the AC to over-fly this waypoint after deploying the first three Mini UAVs. Ordnance advises that another Mini UAV for a 600 ft search altitude is being prepared. NASO 1 conducts a radar search of the area, finds a weak contact near the point that VTUAV 1 was lost, and provides this new information to the TACNAV, who updates the waypoint provided to the pilot moments before. The AC slows the CP140 down to Mini UAV launch speed.
18:46 hrs	The TACNAV deploys three Mini UAVs at five-second intervals. The AC then turns the aircraft towards the next waypoint and advises “one minute back”.
18:47 hrs	A fourth Mini UAV is deployed as the Aurora reaches the assigned waypoint over the downed VTUAV. The first three Mini UAVs appear on the tacplot within 10 seconds of each other and start transmitting video and data. The Hornets check in with the Aurora and advise that they are prepared to attack the vessel with precision guided weapons. The NAVCOM advises the fighters to stand-by while visual confirmation of the threat is acquired.

<table>
<tr><th>Timeline</th><th>Event</th></tr>
<tr><td>18:49 hrs</td><td>The Mini UAVs show images of a fishing boat transiting in the direction of the swell and across the wind lines. The relative wind is at 90° off the bow to port.

As the Mini UAVs approach the boat, men can be seen moving on the deck and a container is shown on the bow of the boat.
The Mini UAV that was launched over the downed VTUAV reports that it has established straight and level flight and is awaiting instructions. The UAV Pilot tasks this Mini UAV with a circular search pattern about the intermittent radar contact at the same location. The UAV Operator notes the instructions and opens a fifth viewing window to monitor imagery of the downed VTUAV.</td></tr>
<tr><td>18:50 hrs</td><td>The UAV Pilot takes control of the first Mini UAV at the scene and using the controls available to him, breaks off the cloverleaf pattern to fully investigate the structure on the boat. The Aurora crew recognizes a medium range JATO UAV mounted inside a transportation container. Both sides of the container are open and men are removing flags and battens from the UAV. The CP140 crew also observe what appears to be a second container mounted mid-ships. This structure is not clearly visible.</td></tr>
<tr><td>18:51 hrs</td><td>The TACNAV and UAV Operator immediately realize that this is the Lethal UAV they are searching for and that the JATO UAV is pointing into the wind and is being readied for launch.
It appears that the personnel on the vessel are aware that they are being observed and a sense of urgency demonstrated by their actions indicates that they know that time is of the essence, considering their overt actions against VTUAV 1.
The UAV Operator scrutinizes the suspicious structure mid-ships concludes that it is probably a second Lethal UAV container.</td></tr>
</table>

Timeline	Event
18:52 hrs	The TACNAV asks the UAV Pilot if it would be possible to crash a Mini UAV into the container. The answer is that the control interface and associated time delays would make it impossible to hit this moving target. However, use of the laser designator on board a Mini UAV would allow targeting for a missile from a CF188. The TACNAV responds by issuing a Flash message requesting an immediate attack by the flight of Hornets. The TACNAV requests that the CP140 over-fly the boat once more at 4000 ft to accommodate the launch of the laser designator Mini UAV. Although these Mini UAVs are much more expensive than the standard EO Mini UAVs, it is clear to the TACNAV that the crew must have one available on an as required basis, and the time required to deploy this device can be saved by launching it now. The TACNAV requests that the laser designator Mini UAV be put into a holding pattern about a waypoint he inserts on the tacplot east of Contact 5. The Hornet Lead confirms the instructions and pre-positions for the attack. The NAVCOM instructs the MALE UAV to remain in the southwest sector of the area until the fighters have returned to Combat Air Patrol (**CAP**) altitude.
18:53 hrs	The TACNAV advises NASO 1 that the Lethal UAV may be launched at any time, and that they are to track the UAV for as long as possible. NASO 1 switches the radar to Air-to-Air mode. The AC suggests that once the Lethal UAV is clear of the terrorist boat, they could establish a trail formation and visually track the UAV inbound to St. John's. At the same time, he advises the crew that the aircraft is one minute back from the launch point for the laser designator Mini UAV.
18:54 hrs	The laser designator Mini UAV is launched and the CP140 retreats to a safe distance from the terrorist vessel. The tacplot indicates the position of the newest Mini UAV.
18:55 hrs	The UAV Pilot establishes control of the laser designator Mini UAV and directs it to a holding pattern at the TACNAV established waypoint. The laser designator is slaved to Contact 5. At the same time, the TACNAV maintains reconnaissance of the terrorist vessel using the previously launched Mini UAVs. VTUAV 2 is directed southeast of Contact 5, to hold away from the Hornet's intended track.
18:56 hrs	The Lethal UAV is launched from the terrorist boat. This is observed by the CP140 UAV crew. NASO 1 commences tracking of the Lethal UAV, but loses contact shortly after it turns to the north. A Flash Message is sent to MOC via SATCOM.

Timeline	Event
18:57 hrs	The crew realize that capture of the terrorist would be beneficial; however, they are concerned about the suspicious container remaining unidentified on the boat. At the same time, the fighters report that they will be ready to commence an attack in one minute. The TACNAV requests that the fighters continue but not arm their weapons. At the same time, the TACNAV requests more information from the UAV Operator. The UAV Operator has turned to Mini UAVs and is diving them towards the boat. The UAV Pilot has descended VTUAV 2 below cloud, and is observing the boat from a range of 3 miles downwind. The video clearly shows that the terrorists are readying a second Lethal UAV and the TACNAV directs the Hornets to "go hot". Although the fighter pilots are using the "big sky" approach to collision avoidance, the CP140 crew dive the Mini UAVs to just above the wave tops to avoid a midair collision. The VTUAV anti-collision strobe light is set to ON as the fighters pass. Although the crew have lost radar contact with Lethal UAV, they believe that the only course of action is to begin a search for this UAV.
18:58 hrs	The terrorist boat is destroyed with one GBU-16, a 1000 lb Laser Guided Bomb (**LGB**). The TACNAV begins the process of setting up a search pattern for the Lethal UAV while the UAV Operator sets the Mini UAVs to self-directed mode.
18:59 hrs	The CP140 UAV crew coordinate with the CPF UAV Controller for the return of VTUAV 2. Although the MALE UAV is able to provide an initial track for the Lethal UAV, it also loses contact. The scenario ends.

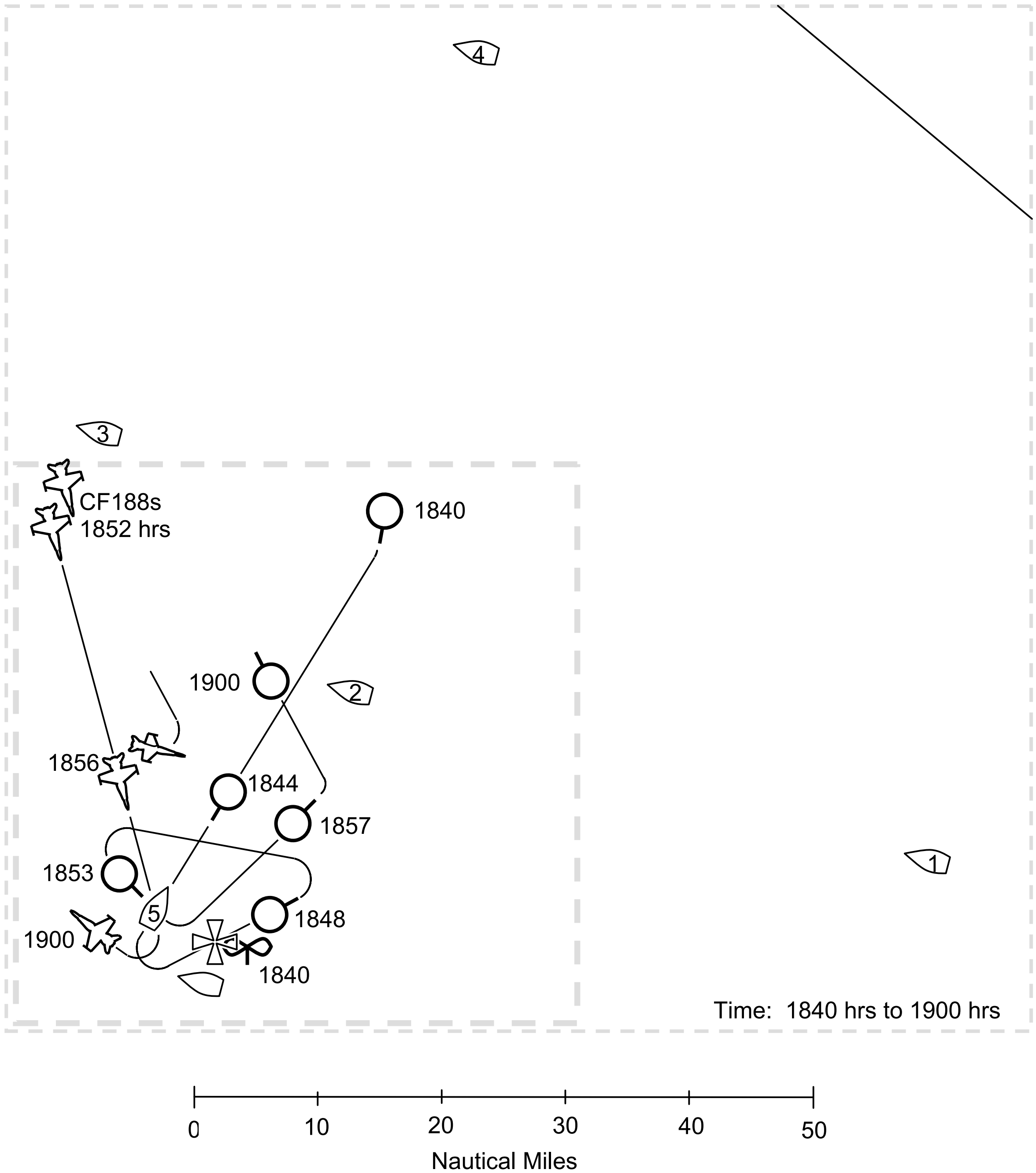


Figure B-6 Detailed Mission Scenario – Part 3

B.8.0 EPILOGUE

Based on direction provided by the CP140 crew, the Modernized CF188 aircraft shot down the Lethal UAV, which was en route to St. John's harbour. The target was determined to be the British destroyer. The RCMP apprehended two individuals who were erecting a laser designator on the slopes of Signal Hill. This laser designator would have provided final control signals to the Lethal UAV to ensure maximum damage.

ANNEX H

TASK INTERRUPTIONS, DELAYS AND SHEDDING WITH IAI ON/OFF – IP/PCT NETWORK PARTS 1, 2 AND 3

14 June 2004

ANNEX H
TASK INTERRUPTIONS, DELAYS AND SHEDDING WITH IAI ON/OFF – IP/PCT NETWORK PARTS 1, 2 AND 3

H.1.0 GENERAL

This Annex contains IP/PCT output from 10 runs of the IPME network. Table H-1 through Table H-16 contain data for each of the three parts of the scenario, with both the IAI augmentation mode OFF (conventional interface) and ON (IAI interface). The data contained herein details the number of times (represented as a %) a task was interrupted, delayed or shed. On occasion, a task was resumed and stopped multiple times, which may provide more occurrences than the number of runs (results greater than 100%). The tables also provide the OSD task number and the two-letter designator of the associated operator (TN – TACNAV, UO – UAV Operator and UP – UAV Pilot). The Top Down HGA designator is provided along with the mean mission time that the interruption, delay or shedding occurred.

H.1.1 IP/PCT NETWORK PART 1 – IAI ON/OFF

Table H-1 IP/PCT NETWORK Part 1 – Tasks Interrupted (IAI Off)

Task Name	Task ID	Clock	Percent Interrupted
140 TN	4.2.4.1	50	10%
144 UO	4.1.14.7	35	60%
146 UP	4.1.14.15	33	70%
148 UO	4.1.14.8	40	40%
151 TN	4.1.13.9	52	30%
162 UP	4.1.14.12	91	30%
164 UP	4.1.14.17	81	30%
168 UO	4.1.14.16	80	40%
192 UP	4.3.1.2	36	50%
204 UP	4.1.14.11	38	30%
209 UP	4.1.12.13	42	230%
210 TN	4.2.4.3	96	20%
215 TN	4.2.3.10	98	10%
218 UP	4.2.3.5	107	50%
221 UO	4.2.4.37	92	20%
247 UP	4.1.21.6	97	20%
248 UP	4.1.21.8	124	10%
250 TN	4.1.21.12	98	20%
256UP	4.1.21.7	62	60%
274 TN	4.3.6.7	317	10%
286 UP	4.2.16.27	334	10%
296 UO	4.2.16.3	371	10%
332 TN	4.3.6.21	356	40%
340 TN	4.3.9.10	346	60%

Table H-1 IP/PCT NETWORK Part 1 – Tasks Interrupted (IAI Off)

Task Name	Task ID	Clock	Percent Interrupted
342 UO IAI	4.3.9.19	377	10%
356 UO	4.2.16.6	389	20%
360 UO	4.2.16.10	369	10%
370 UP	4.2.16.25	302	100%
372 UP	4.2.16.26	335	10%

Table H-2 IP/PCT NETWORK Part 1 – Tasks Delayed (IAI Off)

Task Name	Task ID	Clock	Percent Delayed
140 TN	4.2.4.1	36	20%
144 UO	4.1.14.7	80	10%
145 UO	4.1.14.6	258	10%
148 UO	4.1.14.8	33	20%
151 TN	4.1.13.9	28	110%
162 UP	4.1.14.12	30	150%
164 UP	4.1.14.17	63	60%
168 UO	4.1.14.16	73	30%
186 TN	4.3.1.20	26	90%
204 UP	4.1.14.11	30	10%
208 TN	4.2.4.2	80	10%
209 UP	4.1.12.13	36	60%
210 TN	4.2.4.3	101	10%
215 TN	4.2.3.10	118	10%
218 UP	4.2.3.5	77	120%
220 UP	4.2.3.16	119	30%
221 UO	4.2.4.37	71	40%
222 UO	4.2.3.18	130	10%

Table H-2 IP/PCT NETWORK Part 1 – Tasks Delayed (IAI Off)

Task Name	Task ID	Clock	Percent Delayed
246 UP	4.1.21.2	109	10%
247 UP	4.1.21.6	82	30%
250 TN	4.1.21.12	117	10%
254 UP	4.1.21.9	98	30%
256UP	4.1.21.7	59	70%
258 UP	4.1.21.14	125	20%
286 UP	4.2.16.27	307	30%
330 TN	4.3.6.22	347	10%
332 TN	4.3.6.21	345	60%
340 TN	4.3.9.10	355	40%
342 UO IAI	4.3.9.19	387	30%
346 TN IAI	4.3.9.22	371	40%
358 UO	4.2.16.8	397	10%
370 UP	4.2.16.25	394	100%
372 UP	4.2.16.26	318	70%
376 UP	4.2.15.1	580	10%
378 UP	4.2.15.2	612	30%
384 UP	4.2.15.6	713	10%

Table H-3 IP/PCT NETWORK Part 1 – Tasks Shed (IAI Off)

Task Name	Task ID	Clock	Percent Shed
162 UP	4.1.14.12	78	40%
200 TN	4.1.12.5	32	50%
202 TN	4.1.12.11	36	60%
205 UP	4.1.12.7	32	80%
214 UP	4.2.3.8	72	80%

Table H-3 IP/PCT NETWORK Part 1 – Tasks Shed (IAI Off)

Task Name	Task ID	Clock	Percent Shed
216 UO	4.2.3.9	81	60%
217 UP	4.2.3.1	77	100%
217 UP	4.2.3.1	85	10%
219 UO	4.2.3.2	78	70%
223 UP	4.2.4.35	76	50%
298 TN	4.2.16.29	320	10%
324 TN	4.2.7.20	250	70%
364 TN	4.2.16.18	352	30%
366 UP	4.2.16.19	409	40%
396 UP	4.2.28.2	699	10%

Table H-4 IP/PCT NETWORK Part 1 – Tasks Interrupted (IAI On)

Task Name	Task ID	Clock	Percent Interrupted
140 TN IAI	4.2.4.48	36	10%
144 UO	4.1.14.7	37	10%
146 UP	4.1.14.15	35	80%
148 UO IAI	4.1.14.56	54	10%
150 TN	4.1.13.2	27	40%
151 TN	4.1.13.9	40	30%
152 TN	4.1.13.5	20	30%
156 UO	4.1.18.12	34	10%
164 UP	4.1.14.17	91	10%
166 UO	4.1.14.9	45	20%
168 UO	4.1.14.16	41	40%
204 UP	4.1.14.11	38	40%

Table H-4 IP/PCT NETWORK Part 1 – Tasks Interrupted (IAI On)

Task Name	Task ID	Clock	Percent Interrupted
209 UP	4.1.12.13	41	50%
210 TN	4.2.4.3	35	50%
218 UP	4.2.3.5	55	10%
220 UP	4.2.3.16	139	10%
221 UO	4.2.4.37	33	70%
222 UO	4.2.3.18	90	10%
256UP	4.1.21.7	52	20%
286 UP	4.2.16.27	359	10%
332 TN	4.3.6.21	337	50%
340 TN	4.3.9.10	342	60%
356 UO	4.2.16.6	352	20%
358 UO	4.2.16.8	376	10%
360 UO	4.2.16.10	371	20%
400 UP	4.2.26.23	573	100%

Table H-5 IP/PCT NETWORK Part 1 – Tasks Delayed (IAI On)

Task Name	Task ID	Clock	Percent Delayed
145 UO	4.1.14.6	219	30%
146 UP	4.1.14.15	32	20%
148 UO IAI	4.1.14.56	44	30%
150 TN	4.1.13.2	23	40%
151 TN	4.1.13.9	42	30%
162 UP	4.1.14.12	28	70%
164 UP	4.1.14.17	58	100%
166 UO	4.1.14.9	35	40%

Table H-5 IP/PCT NETWORK Part 1 – Tasks Delayed (IAI On)

Task Name	Task ID	Clock	Percent Delayed
168 UO	4.1.14.16	32	50%
186 TN	4.3.1.20	21	50%
209 UP	4.1.12.13	43	80%
215 TN	4.2.3.10	46	50%
218 UP	4.2.3.5	43	100%
220 UP	4.2.3.16	105	60%
221 UO	4.2.4.37	35	60%
246 UP	4.1.21.2	86	40%
247 UP	4.1.21.6	92	50%
254 UP	4.1.21.9	105	10%
256UP	4.1.21.7	57	110%
286 UP	4.2.16.27	288	20%
332 TN	4.3.6.21	341	50%
340 TN	4.3.9.10	336	50%
342 UO IAI	4.3.9.19	370	10%
346 TN IAI	4.3.9.22	352	50%
358 UO	4.2.16.8	373	10%
370 UP	4.2.16.25	283	200%
372 UP	4.2.16.26	299	50%
452 UP	4.2.27.2	634	60%
454 UP	4.2.27.1	704	20%

Table H-6 IP/PCT NETWORK Part 1 – Tasks Shed (IAI On)

Task Name	Task ID	Clock	Percent Shed
200 TN	4.1.12.5	35	80%
202 TN	4.1.12.11	41	40%
205 UP	4.1.12.7	45	70%
214 UP	4.2.3.44	42	80%
216 UO	4.2.3.45	42	30%
217 UP	4.2.3.1	43	100%
219 UO	4.2.3.2	43	70%
223 UP	4.2.4.35	34	50%
324 TN	4.2.7.20	229	60%
364 TN IAI	4.2.16.33	299	30%
366 UP IAI	4.2.16.34	299	20%
448 UP	4.2.26.32	619	40%
497 UP	4.2.30.16	694	10%

H.1.2 IP/PCT NETWORK PART 2 – IAI ON/OFF

Table H-7 IP/PCT NETWORK Part 2 – Tasks Interrupted (IAI Off)

Task Name	Task ID	Clock	Percent Interrupted
122 TN	21.12.5	11	80%
148 TN	21.13.9	52	10%
150 CR	21.13.10	52	10%
164 TN	21.12.11	72	10%
166 TN	21.12.12	60	10%
168 TN	21.12.13	74	30%
180 TN	21.16.2	108	40%

Table H-7 IP/PCT NETWORK Part 2 – Tasks Interrupted (IAI Off)

Task Name	Task ID	Clock	Percent Interrupted
196 UP	21.17.5	120	30%
198 UO	21.17.39	131	20%
202 TN	21.17.16	112	80%
204 TN	21.17.17	110	30%
212 UP	21.17.6	104	50%
214 UP	21.17.7	128	40%
216 UP	21.17.8	178	10%
218 UO	21.17.14	165	20%
222 TN	21.18.14	155	50%
224 TN	21.18.4	137	30%
228 UO	21.18.7	186	30%
232 UP	21.17.9	153	40%
234 TN	21.17.20	128	60%
236 UP	21.17.10	180	10%
238 UO	21.17.15	166	10%
240 UP	21.17.11	181	20%
242 UP	21.17.26	186	20%
250 UP	21.17.28	208	50%
256 UP	21.17.31	255	190%
258 UO	21.17.35	217	10%
260 UP	21.19.2	213	20%
262 UO	21.19.3	220	10%
268 TN	21.17.21	150	10%
282 TN	21.19.12	22	10%
284 CR	21.19.30	11	10%
288 TN	21.19.13	18	40%
292 UP	21.20.2	346	40%

Table H-7 IP/PCT NETWORK Part 2 – Tasks Interrupted (IAI Off)

Task Name	Task ID	Clock	Percent Interrupted
304 UO	21.20.14	424	10%
306 UO	21.20.9	383	340%
308 UO	21.20.11	383	20%
316 UP	21.20.15	427	280%
344 UP	21.21.8	143	10%
350 UP	21.21.12	149	20%
352 UP	21.21.13	173	30%
354 UP	21.21.17	166	30%
360 UO	21.22.1	458	10%
362 UO	21.22.2	412	50%
364 UO	21.22.3	440	20%
366 UO	21.22.5	435	10%
372 UP	21.22.8	458	30%
410 TN	21.30.2	139	30%
411 UO	21.30.3	151	10%
412 UP	21.30.4	151	20%
414 CR	21.30.5	151	10%
416 UP	21.28.2	211	10%
418 UP	21.28.4	207	40%
419 CR	21.28.5	226	10%
422 UP	21.28.8	244	20%
424 UP	21.28.22	248	20%
425 UP	21.28.21	246	10%
430 UO	21.23.16	586	20%
431 UO	21.23.15	666	20%
432 UO	21.23.5	672	30%
452 UO	21.29.6	325	30%

Table H-7 IP/PCT NETWORK Part 2 – Tasks Interrupted (IAI Off)

Task Name	Task ID	Clock	Percent Interrupted
454 UO	21.29.8	347	10%
458 UP	21.29.11	320	10%
460 UP	21.29.7	333	240%
480 UO	21.26.11	714	30%
484 UP	21.26.6	761	10%
485 UP	21.26.14	792	80%
486 UO	21.26.12	744	10%
491 UO	21.26.13	737	240%
500 UO	21.31.3	366	110%
508 UP	21.31.20	443	80%
510 UO	21.31.8	395	20%
511 UO	21.31.10	410	50%
512 UO	21.31.11	442	10%
518 UO	21.31.15	444	30%
519 UO	21.31.16	448	60%
521 UO	21.31.21	544	10%
523 UO	21.31.22	518	20%
524 UO	21.31.23	537	10%
527 UP	21.31.25	537	30%
528 UO	21.31.26	544	80%
530 UO	21.31.58	594	20%
535 UO	21.34.1	550	20%
536 UO	21.34.2	614	10%
540 TN	21.34.6	592	10%
544 UO	21.34.10	579	30%
575 TN	21.35.2	582	10%
578 CR	21.35.5	582	10%

Table H-7 IP/PCT NETWORK Part 2 – Tasks Interrupted (IAI Off)

Task Name	Task ID	Clock	Percent Interrupted
582 TN	21.35.8	633	20%
584 TN	21.35.9	627	40%
586 TN	21.35.10	633	40%
588 TN	21.35.11	645	20%
592 TN	21.35.15	704	20%
642 UO	21.27.3	1110	20%
644 UP	21.27.4	1042	60%
647 CR	21.27.7	1092	10%
648 UO	21.27.8	1116	10%
650 UP	21.27.10	1086	40%
652 UP	21.27.2	1046	80%
654 UP	21.27.11	1104	10%
662 TN	21.36.2	1069	60%
664 TN	21.36.3	1123	50%

Table H-8 IP/PCT NETWORK Part 2 – Tasks Delayed (IAI Off)

Task Name	Task ID	Clock	Percent Delayed
120 TN	21.12.9	0	10%
122 TN	21.12.5	22	10%
124 TN	21.12.4	17	80%
126 UO	21.12.8	0	10%
147 TN	21.13.8	18	120%
148 TN	21.13.9	45	20%
164 TN	21.12.11	32	100%
166 TN	21.12.12	50	40%
168 TN	21.12.13	57	50%

Table H-8 IP/PCT NETWORK Part 2 – Tasks Delayed (IAI Off)

Task Name	Task ID	Clock	Percent Delayed
176 UP	21.15.9	91	200%
178 UO	21.15.5	91	100%
180 TN	21.16.2	90	100%
194 UP	21.17.2	108	10%
196 UP	21.17.5	102	70%
198 UO	21.17.39	125	10%
200 UO	21.17.4	90	100%
202 TN	21.17.16	90	100%
204 TN	21.17.17	105	90%
206 TN	21.18.1	124	110%
212 UP	21.17.6	113	50%
214 UP	21.17.7	120	70%
216 UP	21.17.8	140	230%
218 UO	21.17.14	175	10%
222 TN	21.18.14	137	90%
224 TN	21.18.4	152	80%
226 TN	21.18.6	150	70%
228 UO	21.18.7	185	20%
232 UP	21.17.9	140	110%
234 TN	21.17.20	120	150%
236 UP	21.17.10	157	30%
238 UO	21.17.15	180	20%
240 UP	21.17.11	166	100%
242 UP	21.17.26	176	130%
244 UO	21.17.24	211	10%
246 UP	21.17.25	228	30%
248 UP	21.17.27	203	120%

Table H-8 IP/PCT NETWORK Part 2 – Tasks Delayed (IAI Off)

Task Name	Task ID	Clock	Percent Delayed
250 UP	21.17.28	208	40%
252 UO	21.17.30	203	10%
256 UP	21.17.31	215	390%
260 UP	21.19.2	164	90%
262 UO	21.19.3	164	10%
264 UP	21.17.33	270	90%
266 UO	21.17.34	330	10%
268 TN	21.17.21	169	60%
282 TN	21.19.12	13	90%
284 CR	21.19.30	13	60%
288 TN	21.19.13	11	210%
290 TN	21.19.14	22	100%
294 UO	21.20.3	345	20%
304 UO	21.20.14	350	10%
306 UO	21.20.9	333	1560%
314 UP	21.20.10	403	40%
316 UP	21.20.15	414	1030%
344 UP	21.21.8	132	10%
346 TN	21.21.11	139	90%
348 UP	21.21.10	135	90%
350 UP	21.21.12	138	100%
352 UP	21.21.13	155	90%
354 UP	21.21.17	155	80%
356 UP	21.21.15	178	100%
358 UP	21.21.16	178	110%
360 UO	21.22.1	385	100%
362 UO	21.22.2	396	10%

Table H-8 IP/PCT NETWORK Part 2 – Tasks Delayed (IAI Off)

Task Name	Task ID	Clock	Percent Delayed
362 UO	21.22.2	434	70%
364 UO	21.22.3	430	80%
366 UO	21.22.5	529	20%
372 UP	21.22.8	569	10%
380 TN	21.24.5	577	20%
380 TN	21.24.5	589	10%
390 UO	21.24.11	611	30%
410 TN	21.30.2	137	40%
412 UP	21.30.4	144	20%
416 UP	21.28.2	208	10%
418 UP	21.28.4	196	90%
422 UP	21.28.8	222	60%
424 UP	21.28.22	228	60%
425 UP	21.28.21	261	20%
426 UP	21.28.20	273	20%
428 UO	21.23.18	552	100%
430 UO	21.23.16	572	40%
431 UO	21.23.15	605	30%
432 UO	21.23.5	629	30%
434 UP	21.23.17	572	10%
436 UO	21.23.6	693	20%
452 UO	21.29.6	328	10%
454 UO	21.29.8	346	10%
458 UP	21.29.11	330	20%
460 UP	21.29.7	299	410%
462 UO	21.29.12	331	10%
475 UP	21.26.1	670	100%

Table H-8 IP/PCT NETWORK Part 2 – Tasks Delayed (IAI Off)

Task Name	Task ID	Clock	Percent Delayed
480 UO	21.26.11	688	50%
482 UP	21.26.4	722	10%
485 UP	21.26.14	712	250%
486 UO	21.26.12	688	60%
490 UO	21.26.9	767	20%
491 UO	21.26.13	696	390%
492 TN	21.26.16	728	20%
500 UO	21.31.3	362	310%
502 UO	21.31.4	390	10%
505 UP	21.31.7	390	20%
506 UP	21.31.19	392	20%
508 UP	21.31.20	392	410%
510 UO	21.31.8	388	60%
511 UO	21.31.10	401	70%
512 UO	21.31.11	388	40%
514 UO	21.31.12	453	10%
518 UO	21.31.15	410	40%
519 UO	21.31.16	423	70%
520 UO	21.31.17	456	80%
521 UO	21.31.21	471	40%
522 UP	21.31.18	447	10%
523 UO	21.31.22	488	40%
524 UO	21.31.23	505	50%
528 UO	21.31.26	546	40%
530 UO	21.31.58	542	80%
535 UO	21.34.1	537	100%
536 UO	21.34.2	570	30%

Table H-8 IP/PCT NETWORK Part 2 – Tasks Delayed (IAI Off)

Task Name	Task ID	Clock	Percent Delayed
540 TN	21.34.6	586	10%
544 UO	21.34.10	592	40%
575 TN	21.35.2	577	30%
580 TN	21.35.7	642	20%
582 TN	21.35.8	616	60%
584 TN	21.35.9	612	100%
586 TN	21.35.10	612	50%
588 TN	21.35.11	621	40%
589 TN	21.35.12	638	30%
593 TN	21.35.16	687	20%
617 UO	21.38.11	1130	10%
640 UP	21.27.1	1020	100%
644 UP	21.27.4	1084	10%
647 CR	21.27.7	1116	10%
648 UO	21.27.8	1046	10%
649 TN	21.27.9	1116	10%
650 UP	21.27.10	1046	60%
652 UP	21.27.2	1038	90%
654 UP	21.27.11	1058	100%
660 TN	21.36.1	1052	100%
662 TN	21.36.2	1107	10%
662 TN	21.36.2	1140	10%
664 TN	21.36.3	1139	20%
675 NG	21.45	67	40%
677 NG	21.47	110	50%
680 PG	21.64	90	100%
682 NG	21.66	150	10%

Table H-8 IP/PCT NETWORK Part 2 – Tasks Delayed (IAI Off)

Task Name	Task ID	Clock	Percent Delayed
687 OG	21.83	348	10%
688 NG	21.70	109	40%
689 NG	21.71	199	10%
690 OG	21.84	414	60%
691 OG	21.85	552	20%
692 NG	21.50	568	10%
694 NG	21.61	137	20%
695 NG	21.60	168	50%
696 NG	21.72	191	20%
698 OG	21.86	552	20%
703 PG	21.89	1078	10%
705 OG	21.77	556	60%
711 NG	21.55	1106	10%
716 OG	21.62	1105	20%
718 NG	21.63	1132	20%
719 NG	21.59	1133	10%
720 PG	21.90	1078	10%

Table H-9 IP/PCT NETWORK Part 2 – Tasks Shed (IAI Off)

Task Name	Task ID	Clock	Percent Shed
132 TN	21.12.2	1	100%
142 TN	21.13.6	12	90%
144 UP	21.13.5	12	90%
152 UO	21.13.11	52	10%
154 UP	21.13.12	52	10%
158 TN	21.13.15	55	50%

Table H-9 IP/PCT NETWORK Part 2 – Tasks Shed (IAI Off)

Task Name	Task ID	Clock	Percent Shed
188 TN	21.16.7	108	40%
190 UO	21.16.8	130	20%
192 UP	21.16.6	130	20%
203 UO	21.17.18	108	70%
205 UP	21.17.19	110	100%
220 TN	21.17.13	142	100%
230 UP	21.18.8	185	80%
232 UP	21.17.9	164	10%
240 UP	21.17.11	186	20%
256 UP	21.17.31	222	20%
260 UP	21.19.2	199	10%
270 UO	21.17.22	150	30%
272 UP	21.17.23	150	40%
276 TN	21.19.7	8	100%
278 UP	21.19.6	10	40%
280 UO	21.19.8	8	100%
286 TN	21.19.29	11	50%
298 UO	21.20.7	330	80%
300 TN	21.20.6	361	40%
306 UO	21.20.9	359	540%
310 TN	21.20.12	341	50%
312 UP	21.20.13	357	70%
316 UP	21.20.15	519	150%
326 UO	21.16.11	434	20%
336 UO	21.21.6	125	60%
338 TN	21.21.5	125	90%
340 UP	21.21.4	125	80%

Table H-9 IP/PCT NETWORK Part 2 – Tasks Shed (IAI Off)

Task Name	Task ID	Clock	Percent Shed
356 UP	21.21.15	190	10%
358 UP	21.21.16	200	10%
368 TN	21.22.6	545	20%
378 TN	21.24.3	572	30%
392 TN	21.24.10	620	60%
396 TN	21.24.13	624	20%
402 UO	21.24.15	649	20%
417 UO	21.28.3	196	60%
418 UP	21.28.4	213	10%
420 TN	21.28.6	226	20%
421 UO	21.28.7	225	70%
437 TN	21.23.7	651	40%
448 UO	21.29.5	310	30%
450 UP	21.29.3	310	10%
455 UP	21.29.10	345	10%
460 UP	21.29.7	445	30%
469 TN	21.24.23	759	10%
485 UP	21.26.14	784	100%
488 TN	21.26.8	752	10%
500 UO	21.31.3	387	440%
504 UP	21.31.6	386	20%
508 UP	21.31.20	461	20%
516 UP	21.31.14	421	40%
525 TN	21.31.24	537	20%
531 TN	21.31.59	571	40%
532 UP	21.31.61	570	30%
537 TN	21.34.3	563	50%

Table H-9 IP/PCT NETWORK Part 2 – Tasks Shed (IAI Off)

Task Name	Task ID	Clock	Percent Shed
538 UP	21.34.4	568	40%
543 UO	21.34.7	584	50%
576 UO	21.35.3	582	30%
577 UP	21.35.4	582	20%
601 TN	21.37.3	1044	20%
608 TN	21.38.3	1117	10%
618 TN	21.38.10	1130	30%
625 UP	21.38.19	1146	10%
634 TN	21.39.7	1152	10%
645 UO	21.27.5	1078	80%
646 TN	21.27.6	1092	30%
654 UP	21.27.11	1097	10%

Table H-10 IP/PCT NETWORK Part 2 – Tasks Interrupted (IAI On)

Task Name	Task ID	Clock	Percent Interrupted
124 TN	21.12.4	8	30%
126 UO	21.12.8	8	20%
148 TN	21.13.9	43	10%
150 CR	21.13.10	43	10%
164 TN	21.12.11	11	30%
166 TN	21.12.12	18	60%
176 UP	21.15.9	34	30%
178 UO	21.15.5	34	40%
180 TN	21.16.2	38	40%
194 UP	21.17.2	62	10%
196 UP	21.17.5	41	30%

Table H-10 IP/PCT NETWORK Part 2 – Tasks Interrupted (IAI On)

Task Name	Task ID	Clock	Percent Interrupted
202 TN	21.17.16	53	100%
206 TN	21.18.1	81	10%
212 UP	21.17.6	51	30%
216 UP	21.17.8	81	40%
218 UO	21.17.14	81	40%
226 TN	21.18.6	73	60%
228 UO	21.18.7	83	60%
232 UP	21.17.9	69	40%
234 TN	21.17.20	90	40%
236 UP	21.17.10	121	30%
238 UO	21.17.15	121	20%
240 UP	21.17.11	117	20%
242 UP IAI	21.17.54	122	10%
244 UO	21.17.24	134	20%
246 UP	21.17.25	125	20%
248 UP	21.17.27	138	10%
250 UP	21.17.28	130	60%
252 UO	21.17.30	122	10%
256 UP	21.17.31	128	160%
260 UP	21.19.2	142	10%
262 UO	21.19.3	158	10%
264 UP	21.17.33	203	20%
268 TN	21.17.21	137	20%
282 TN	21.19.12	18	10%
288 TN	21.19.26	9	40%
292 UP	21.20.2	244	130%
306 UO	21.20.17	287	410%

Table H-10 IP/PCT NETWORK Part 2 – Tasks Interrupted (IAI On)

Task Name	Task ID	Clock	Percent Interrupted
308 UO	21.20.16	244	10%
314 UP	21.20.10	315	50%
316 UP	21.20.15	332	200%
342 UO	21.21.7	116	40%
344 UP	21.21.8	116	50%
346 TN	21.21.11	129	10%
348 UP	21.21.10	123	20%
350 UP	21.21.12	131	10%
352 UP	21.21.13	129	50%
356 UP	21.21.15	141	10%
362 UO IAI	21.22.12	320	70%
364 UO	21.22.3	350	40%
372 UP	21.22.8	369	20%
390 UO	21.24.11	564	30%
410 TN	21.30.2	132	30%
411 UO	21.30.3	129	60%
412 UP	21.30.4	129	60%
414 CR	21.30.5	132	20%
418 UP	21.28.4	174	10%
419 CR	21.28.5	174	10%
424 UP	21.28.22	194	10%
434 UP	21.23.17	507	10%
460 UP	21.29.7	223	120%
477 TN	21.26.10	530	30%
480 UO	21.26.11	564	30%
485 UP	21.26.14	582	90%
490 UO	21.26.9	544	20%

Table H-10 IP/PCT NETWORK Part 2 – Tasks Interrupted (IAI On)

Task Name	Task ID	Clock	Percent Interrupted
491 UO	21.26.13	573	110%
492 TN	21.26.16	589	10%
500 UO	21.31.38	286	140%
502 UO	21.31.37	287	10%
508 UP	21.31.20	291	40%
518 UO	21.31.15	290	20%
519 UO	21.31.16	301	40%
520 UO	21.31.17	345	20%
521 UO	21.31.21	328	40%
522 UP	21.31.18	312	80%
523 UO IAI	21.31.57	347	30%
524 UO	21.31.23	342	10%
527 UP	21.31.25	350	50%
528 UO	21.31.26	352	60%
535 UO	21.34.13	407	10%
536 UO	21.34.14	381	10%
555 UO	21.32.13	891	10%
564 TN	21.33.3	857	20%
575 TN	21.35.2	357	40%
578 CR	21.35.5	357	40%
582 TN	21.35.8	392	10%
592 TN	21.35.15	512	10%
593 TN	21.35.16	512	20%
642 UO	21.27.3	869	60%
648 UO	21.27.8	891	20%
649 TN	21.27.9	858	10%
650 UP	21.27.10	879	20%

Table H-10 IP/PCT NETWORK Part 2 – Tasks Interrupted (IAI On)

Task Name	Task ID	Clock	Percent Interrupted
652 UP	21.27.2	852	90%
654 UP	21.27.11	881	10%
660 TN	21.36.1	903	20%
662 TN	21.36.2	888	30%
664 TN	21.36.3	902	10%

Table H-11 IP/PCT NETWORK Part 2 – Tasks Delayed (IAI On)

Task Name	Task ID	Clock	Percent Delayed
120 TN	21.12.9	0	10%
124 TN	21.12.4	9	50%
126 UO	21.12.8	0	10%
147 TN	21.13.8	18	60%
148 TN	21.13.9	38	10%
164 TN	21.12.11	9	50%
166 TN	21.12.12	11	50%
168 TN IAI	21.12.20	17	30%
170 TN	21.15.1	40	50%
176 UP	21.15.9	26	140%
178 UO	21.15.5	26	60%
180 TN	21.16.2	25	100%
194 UP	21.17.2	43	30%
196 UP	21.17.5	46	40%
200 UO	21.17.4	25	50%
202 TN	21.17.16	25	100%
204 TN	21.17.44	58	60%
206 TN	21.18.1	41	100%

Table H-11 IP/PCT NETWORK Part 2 – Tasks Delayed (IAI On)

Task Name	Task ID	Clock	Percent Delayed
212 UP	21.17.6	38	60%
214 UP IAI	21.17.50	55	60%
216 UP	21.17.8	65	40%
222 TN IAI	21.18.15	55	30%
224 TN IAI	21.18.13	55	100%
226 TN	21.18.6	56	50%
228 UO	21.18.7	69	50%
232 UP	21.17.9	79	60%
234 TN	21.17.20	55	80%
236 UP	21.17.10	81	60%
238 UO	21.17.15	83	30%
240 UP	21.17.11	110	50%
242 UP IAI	21.17.54	129	30%
244 UO	21.17.24	96	40%
248 UP	21.17.27	101	130%
250 UP	21.17.28	133	60%
252 UO	21.17.30	126	70%
256 UP	21.17.31	150	300%
258 UO	21.17.35	146	50%
260 UP	21.19.2	98	120%
262 UO	21.19.3	167	10%
264 UP	21.17.33	146	60%
266 UO	21.17.34	180	20%
268 TN	21.17.21	116	10%
282 TN	21.19.12	7	130%
288 TN	21.19.26	7	50%
290 TN	21.19.27	10	40%

Table H-11 IP/PCT NETWORK Part 2 – Tasks Delayed (IAI On)

Task Name	Task ID	Clock	Percent Delayed
292 UP	21.20.2	236	10%
294 UO	21.20.3	236	20%
296 UP	21.20.23	287	20%
306 UO	21.20.17	244	130%
314 UP	21.20.10	332	20%
316 UP	21.20.15	319	790%
342 UO	21.21.7	117	40%
344 UP	21.21.8	129	10%
346 TN	21.21.11	121	50%
348 UP	21.21.10	121	20%
350 UP	21.21.12	131	10%
352 UP	21.21.13	130	90%
354 UP IAI	21.21.26	126	40%
356 UP	21.21.15	142	120%
358 UP	21.21.16	138	60%
360 UO IAI	21.22.11	325	30%
362 UO IAI	21.22.12	368	20%
364 UO	21.22.3	332	100%
366 UO	21.22.14	376	20%
372 UP	21.22.8	379	10%
390 UO	21.24.11	571	20%
410 TN	21.30.2	122	40%
411 UO	21.30.3	133	20%
412 UP	21.30.4	131	60%
414 CR	21.30.5	138	10%
416 UP	21.28.15	145	20%
418 UP	21.28.4	145	100%

Table H-11 IP/PCT NETWORK Part 2 – Tasks Delayed (IAI On)

Task Name	Task ID	Clock	Percent Delayed
422 UP	21.28.8	165	60%
424 UP	21.28.22	185	10%
425 UP IAI	21.28.23	190	10%
426 UP IAI	21.28.24	180	10%
436 UO	21.23.6	526	30%
438 UP	21.23.8	521	50%
452 UO IAI	21.29.16	225	20%
458 UP	21.29.11	211	20%
460 UP	21.29.7	208	370%
462 UO IAI	21.29.18	252	10%
475 UP	21.26.1	513	100%
480 UO	21.26.11	555	50%
485 UP	21.26.14	541	290%
486 UO	21.26.12	530	80%
490 UO	21.26.9	547	90%
491 UO	21.26.13	550	260%
500 UO	21.31.38	254	670%
502 UO	21.31.37	279	10%
505 UP	21.31.41	261	30%
506 UP	21.31.19	284	20%
508 UP	21.31.20	284	310%
519 UO	21.31.16	332	10%
520 UO	21.31.17	314	50%
521 UO	21.31.21	341	50%
522 UP	21.31.18	299	10%
523 UO IAI	21.31.57	336	50%
524 UO	21.31.23	348	60%

Table H-11 IP/PCT NETWORK Part 2 – Tasks Delayed (IAI On)

Task Name	Task ID	Clock	Percent Delayed
527 UP	21.31.25	342	30%
528 UO	21.31.26	352	30%
530 UO	21.31.27	358	60%
535 UO	21.34.13	351	90%
536 UO	21.34.14	372	60%
540 TN	21.34.18	380	10%
544 UO	21.34.22	377	50%
555 UO	21.32.13	884	30%
560 TN	21.32.17	900	60%
561 UO	21.32.18	900	40%
564 TN	21.33.3	853	10%
582 TN	21.35.8	412	70%
584 TN	21.35.9	391	70%
586 TN	21.35.10	391	70%
588 TN	21.35.11	399	40%
589 TN	21.35.12	456	20%
593 TN	21.35.16	530	10%
623 TN	21.38.15	1124	10%
640 UP	21.27.12	847	20%
644 UP	21.27.13	843	60%
648 UO	21.27.8	888	20%
649 TN	21.27.9	852	30%
650 UP	21.27.10	852	50%
652 UP	21.27.2	873	40%
654 UP	21.27.11	857	80%
660 TN	21.36.1	858	100%
662 TN	21.36.2	912	50%

Table H-11 IP/PCT NETWORK Part 2 – Tasks Delayed (IAI On)

Task Name	Task ID	Clock	Percent Delayed
664 TN	21.36.3	912	40%
675 NG	21.45	40	30%
677 NG	21.47	45	10%
678 NG	21.48	25	20%
679 NG	21.49	402	10%
680 PG	21.64	25	40%
681 PG	21.65	36	30%
683 NG	21.67	118	10%
684 NG	21.68	6	50%
688 NG	21.70	99	50%
689 NG	21.71	150	30%
690 OG	21.84	325	30%
692 NG	21.50	527	10%
694 NG	21.61	122	30%
696 NG	21.72	145	10%
701 PG	21.75	254	10%
702 PG	21.88	515	40%
703 PG	21.89	847	20%
706 NG	21.78	377	30%
709 NG	21.53	903	20%
720 PG	21.90	847	20%
721 PG	21.91	868	10%
722 NG	21.92	896	10%

Table H-12 IP/PCT NETWORK Part 2 – Tasks Shed (IAI On)

Task Name	Task ID	Clock	Percent Shed
132 TN	21.12.2	1	100%
142 TN	21.13.6	12	90%
152 UO	21.13.11	43	10%
154 UP	21.13.12	43	10%
158 TN	21.13.18	38	90%
162 UP	21.13.22	47	20%
172 UO	21.15.2	42	50%
174 UP	21.15.3	42	50%
188 TN	21.16.7	40	40%
190 UO	21.16.8	38	10%
202 TN	21.17.16	25	10%
203 UO	21.17.45	41	40%
205 UP	21.17.46	41	70%
220 TN	21.17.13	69	100%
222 TN IAI	21.18.15	56	10%
224 TN IAI	21.18.13	55	10%
230 UP	21.18.8	69	80%
234 TN	21.17.20	55	10%
250 UP	21.17.28	130	20%
256 UP	21.17.31	154	50%
270 UO	21.17.22	117	40%
272 UP	21.17.23	97	50%
276 TN	21.19.15	6	70%
280 UO	21.19.17	6	80%
286 TN	21.19.11	7	100%
298 UO	21.20.26	265	30%

Table H-12 IP/PCT NETWORK Part 2 – Tasks Shed (IAI On)

Task Name	Task ID	Clock	Percent Shed
306 UO	21.20.17	301	350%
312 UP	21.20.18	285	10%
316 UP	21.20.15	353	70%
326 UO	21.16.11	376	50%
328 UP	21.16.13	386	10%
336 UO	21.21.21	122	20%
338 TN	21.21.20	114	60%
340 UP	21.21.19	114	70%
368 TN	21.22.15	380	30%
370 UP	21.22.16	380	30%
378 TN	21.24.3	518	40%
392 TN	21.24.10	564	10%
396 TN	21.24.13	585	10%
412 UP	21.30.4	130	10%
417 UO	21.28.16	146	40%
420 TN	21.28.6	156	40%
421 UO	21.28.7	158	30%
437 TN	21.23.7	503	80%
444 UP	21.23.25	512	60%
448 UO	21.29.5	211	20%
450 UP	21.29.3	210	20%
455 UP	21.29.10	208	20%
460 UP	21.29.7	364	10%
485 UP	21.26.14	870	10%
488 TN	21.26.8	564	50%
491 UO	21.26.13	564	10%
500 UO	21.31.38	316	170%

Table H-12 IP/PCT NETWORK Part 2 – Tasks Shed (IAI On)

Task Name	Task ID	Clock	Percent Shed
503 TN	21.31.40	287	10%
504 UP	21.31.39	260	30%
508 UP	21.31.20	317	60%
516 UP	21.31.47	263	20%
525 TN	21.31.24	342	50%
531 TN	21.31.28	377	20%
532 UP	21.31.29	357	70%
537 TN	21.34.17	379	10%
538 UP	21.34.16	354	30%
541 UP	21.34.20	355	40%
543 UO	21.34.21	376	40%
556 TN	21.32.12	885	30%
562 UP	21.32.16	900	30%
568 TN	21.33.6	868	10%
576 UO	21.35.3	356	80%
577 UP	21.35.4	357	40%
645 UO	21.27.14	852	50%

H.1.3 IP/PCT NETWORK PART 3 – IAI ON/OFF

Table H-13 IP/PCT NETWORK Part 3 – Tasks Interrupted (IAI Off)

Task Name	Task ID	Clock	Percent Interrupted
124 TN	27.2.4	88	10%
177 TN	27.5.19	130	110%
180 TN	27.7.2	120	70%
192 TN	27.12.1	144	50%
218 TN	27.6.17	120	30%
235 TN	27.11.8	181	20%
245 TN	27.10.3	245	70%
319 TN	27.15.7	370	20%
320 UP	27.15.6	375	10%
321 UP	27.15.8	396	20%
335 UP	27.17.1	411	10%
336 UP	27.17.2	405	40%
337 UP	27.17.11	415	20%
338 UP	27.17.13	421	40%
339 UP	27.17.15	419	20%
340 UP	27.17.16	431	30%
345 UO	27.17.5	414	10%
346 UO	27.17.10	416	20%
360 TN	27.19.8	432	30%
362 TN	27.19.7	438	30%
363 UO	27.19.6	454	10%
364 UP	27.19.9	433	20%
369 TN	27.39.3	469	20%
371 TN	27.39.5	519	10%

Table H-13 IP/PCT NETWORK Part 3 – Tasks Interrupted (IAI Off)

Task Name	Task ID	Clock	Percent Interrupted
375 UO	27.18.1	476	40%
376 TN	27.18.2	469	40%
377 UP	27.18.3	476	50%
380 UO	27.18.4	487	20%
381 TN	27.18.5	486	10%
382 UP	27.18.10	479	40%
385 UP	27.22.3	480	20%
387 UP	27.22.9	509	110%
391 UP	27.22.5	518	10%
392 UO	27.22.8	516	50%
395 UO	27.18.8	512	10%
400 UP	27.18.12	571	10%
402 UO	27.18.15	522	20%
405 UO	27.18.18	530	10%
510 UP	27.30.3	823	10%
519 UP	27.30.9	866	70%
524 UP	27.31.1	812	10%
525 UP	27.31.3	822	10%
527 UP	27.31.2	832	50%
530 UO	27.32.2	871	100%
531 TN	27.32.3	871	100%
532 UP	27.32.4	871	100%
543 UO	27.32.7	919	20%

Table H-14 IP/PCT NETWORK Part 3 – Tasks Delayed (IAI Off)

Task Name	Task ID	Clock	Percent Delayed
151 TN	27.5.11	87	30%
177 TN	27.5.19	147	10%
180 TN	27.7.2	119	30%
192 TN	27.12.1	144	30%
215 TN	27.6.15	105	10%
218 TN	27.6.17	119	70%
230 TN	27.11.2	125	70%
297 TN	27.14.16	248	30%
307 TN	27.13.17	312	10%
320 UP	27.15.6	349	80%
321 UP	27.15.8	351	30%
330 TN	27.16.6	369	60%
331 UP	27.16.7	369	80%
335 UP	27.17.1	395	50%
336 UP	27.17.2	404	50%
337 UP	27.17.11	405	60%
338 UP	27.17.13	414	90%
339 UP	27.17.15	415	70%
340 UP	27.17.16	421	80%
346 UO	27.17.10	405	50%
347 UO	27.17.14	415	70%
352 UP	27.17.19	441	10%
360 TN	27.19.8	433	60%
362 TN	27.19.7	431	40%
363 UO	27.19.6	441	10%

Table H-14 IP/PCT NETWORK Part 3 – Tasks Delayed (IAI Off)

Task Name	Task ID	Clock	Percent Delayed
364 UP	27.19.9	433	60%
369 TN	27.39.3	473	50%
371 TN	27.39.5	510	10%
375 UO	27.18.1	452	10%
376 TN	27.18.2	451	40%
377 UP	27.18.3	452	40%
380 UO	27.18.4	475	30%
381 TN	27.18.5	475	50%
382 UP	27.18.10	482	70%
385 UP	27.22.3	479	20%
386 UP	27.22.4	485	70%
387 UP	27.22.9	496	260%
388 UO	27.22.2	479	50%
390 TN	27.22.6	502	10%
392 UO	27.22.8	516	20%
395 UO	27.18.8	500	40%
396 TN	27.18.7	500	10%
397 UP	27.18.9	500	40%
399 UP	27.18.11	508	20%
402 UO	27.18.15	521	20%
404 UP	27.18.13	524	20%
405 UO	27.18.18	525	40%
406 TN	27.18.17	526	10%
416 UO	27.20.6	544	50%
418 UP	27.20.7	544	60%
428 TN	27.23.3	580	30%
463 TN	27.27.4	843	100%

Table H-14 IP/PCT NETWORK Part 3 – Tasks Delayed (IAI Off)

Task Name	Task ID	Clock	Percent Delayed
479 TN	27.28.12	765	50%
481 TN	27.28.17	777	20%
482 TN	27.28.13	756	130%
496 UP	27.29.5	835	10%
510 UP	27.30.3	812	10%
512 UP	27.30.4	821	20%
519 UP	27.30.9	873	20%
525 UP	27.31.3	814	20%
527 UP	27.31.2	836	40%
539 UP	27.33.12	993	10%
544 UP	27.32.8	892	10%
545 UO	27.32.10	908	80%
553 UP	27.33.18	996	20%
558 UP	27.35.6	1089	10%
560 UO	27.34.3	942	10%
562 UP	27.34.4	942	10%

Table H-15 IP/PCT NETWORK Part 3 – Tasks Interrupted (IAI On)

Task Name	Task ID	Clock	Percent Interrupted
124 TN	27.2.4	86	20%
151 TN	27.5.11	88	40%
177 TN	27.5.19	138	180%
180 TN	27.7.2	116	60%
192 TN	27.12.1	136	80%
215 TN	27.6.15	89	30%
218 TN	27.6.17	118	40%

Table H-15 IP/PCT NETWORK Part 3 – Tasks Interrupted (IAI On)

Task Name	Task ID	Clock	Percent Interrupted
336 UP	27.17.2	372	70%
338 UP	27.17.13	393	50%
340 UP	27.17.16	406	30%
360 TN	27.19.8	411	20%
362 TN	27.19.7	415	20%
364 UP	27.19.9	405	70%
369 TN	27.39.3	476	10%
371 TN	27.39.5	483	20%
375 UO	27.18.1	440	10%
376 TN	27.18.2	418	10%
377 UP	27.18.3	420	20%
380 UO	27.18.4	451	60%
381 TN	27.18.5	462	10%
382 UP	27.18.10	451	80%
385 UP	27.22.3	452	60%
387 UP	27.22.9	500	70%
388 UO	27.22.2	467	20%
390 TN	27.22.6	472	20%
392 UO	27.22.8	489	50%
395 UO	27.18.8	478	10%
396 TN	27.18.7	478	10%
402 UO	27.18.15	485	20%
405 UO	27.18.18	497	10%
463 TN	27.27.4	813	80%
510 UP	27.30.3	776	30%
519 UP	27.30.9	843	70%
524 UP	27.31.1	786	10%

Table H-15 IP/PCT NETWORK Part 3 – Tasks Interrupted (IAI On)

Task Name	Task ID	Clock	Percent Interrupted
525 UP	27.31.3	775	20%
530 UO	27.32.2	838	80%
531 TN	27.32.3	838	80%
532 UP	27.32.4	838	90%

Table H-16 IP/PCT NETWORK Part 3 – Tasks Shed (IAI On)

Task Name	Task ID	Clock	Percent Shed
151 TN	27.5.11	86	60%
177 TN	27.5.19	141	10%
180 TN	27.7.2	117	40%
192 TN	27.12.1	139	30%
215 TN	27.6.15	90	20%
218 TN	27.6.17	115	60%
230 TN	27.11.2	123	60%
307 TN	27.13.22	301	20%
320 UP	27.15.15	318	50%
321 UP	27.15.17	321	50%
337 UP	27.17.11	382	20%
338 UP	27.17.13	383	90%
339 UP	27.17.15	382	60%
340 UP	27.17.16	398	70%
360 TN	27.19.8	396	30%
362 TN	27.19.7	399	70%
364 UP	27.19.9	396	80%
369 TN	27.39.3	471	30%
371 TN	27.39.5	489	10%

Table H-16 IP/PCT NETWORK Part 3 – Tasks Shed (IAI On)

Task Name	Task ID	Clock	Percent Shed
375 UO	27.18.1	418	10%
376 TN	27.18.2	427	30%
377 UP	27.18.3	436	10%
380 UO	27.18.4	453	20%
382 UP	27.18.10	448	40%
385 UP	27.22.3	443	10%
386 UP	27.22.4	449	90%
387 UP	27.22.9	463	340%
388 UO	27.22.2	443	50%
392 UO	27.22.8	483	40%
395 UO	27.18.8	463	50%
396 TN	27.18.7	475	20%
397 UP	27.18.9	458	80%
399 UP	27.18.11	478	30%
402 UO	27.18.15	489	20%
403 TN	27.18.14	485	30%
405 UO	27.18.18	498	40%
407 UP	27.18.16	491	10%
412 UP	27.20.4	507	10%
416 UO	27.20.6	512	100%
418 UP	27.20.7	514	50%
428 TN	27.23.3	546	20%
441 UP	27.24.2	587	10%
463 TN	27.27.4	809	230%
477 TN	27.28.9	719	10%
479 TN	27.28.12	724	50%
480 TN	27.28.14	732	30%

Table H-16 IP/PCT NETWORK Part 3 – Tasks Shed (IAI On)

Task Name	Task ID	Clock	Percent Shed
481 TN	27.28.17	762	10%
482 TN	27.28.13	726	80%
492 UP	27.29.13	802	10%
503 TN	27.29.15	806	10%
507 UO	27.29.22	851	20%
508 TN	27.29.23	851	20%
509 UP	27.29.21	851	10%
510 UP	27.30.3	771	40%
512 UP	27.30.4	778	20%
519 UP	27.30.9	827	40%
525 UP	27.31.3	771	20%
539 UP	27.33.12	923	10%
544 UP	27.32.14	853	20%
546 TN	27.32.9	859	20%
547 UP	27.32.11	855	60%
553 UP	27.33.18	937	40%
556 UO	27.35.7	1040	10%

ANNEX G

IP/PCT TASK NETWORK OUTPUT

14 June 2004

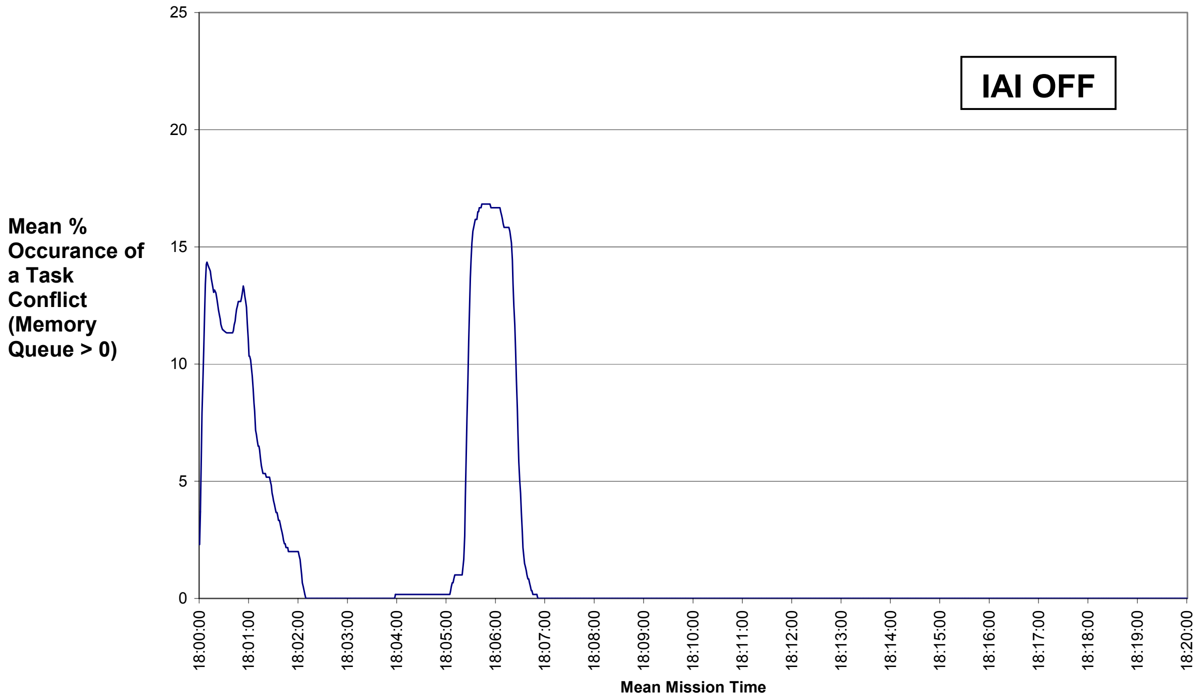
ANNEX G
IP/PCT TASK NETWORK OUTPUT

G.1.0 GENERAL

Table 1 provides a list of the Network Output diagrams in this Annex as well as cross-references to the location of each diagram.

Table 1 Network Output Diagrams

Table 1 Network Output Diagrams



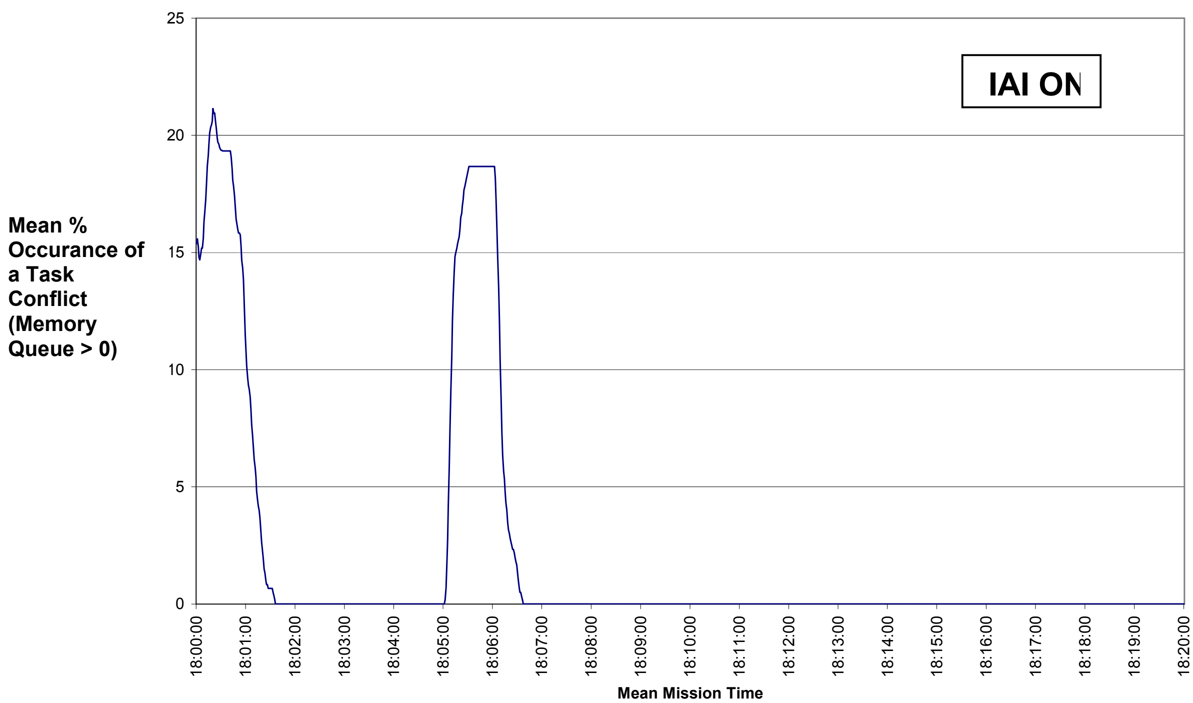


Figure 1 Scenario Part 1 – Task Conflict Parameter (TACNAV)

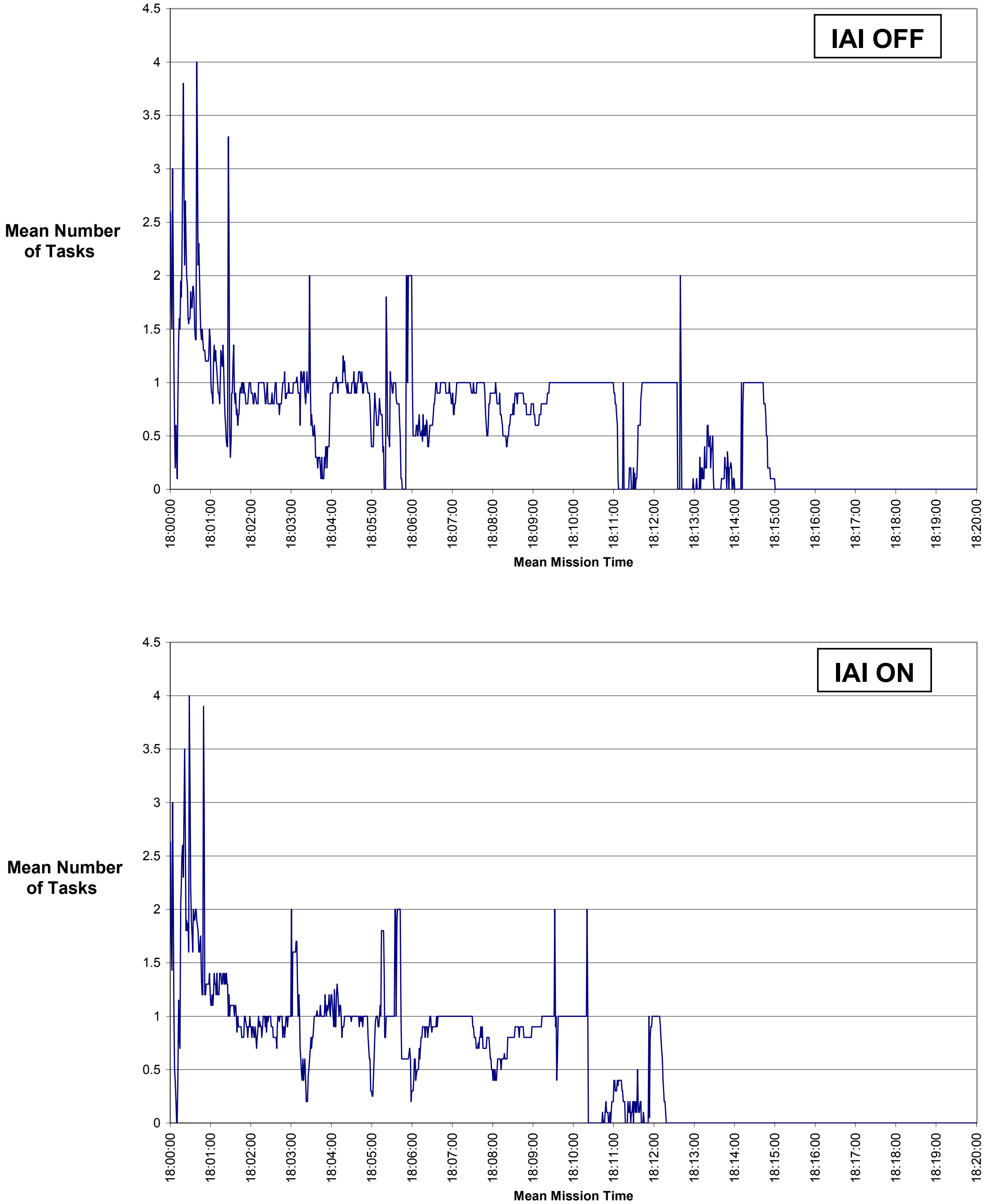
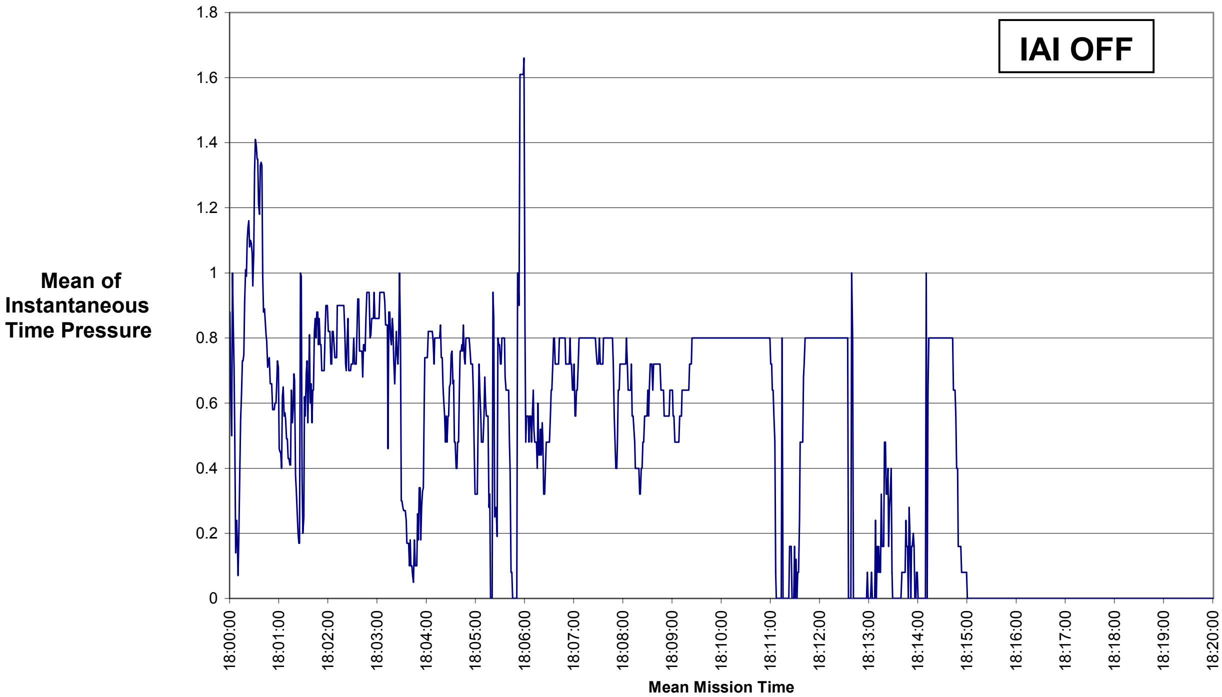


Figure 2 Scenario Part 1 – Number of Ongoing Tasks (TACNAV)



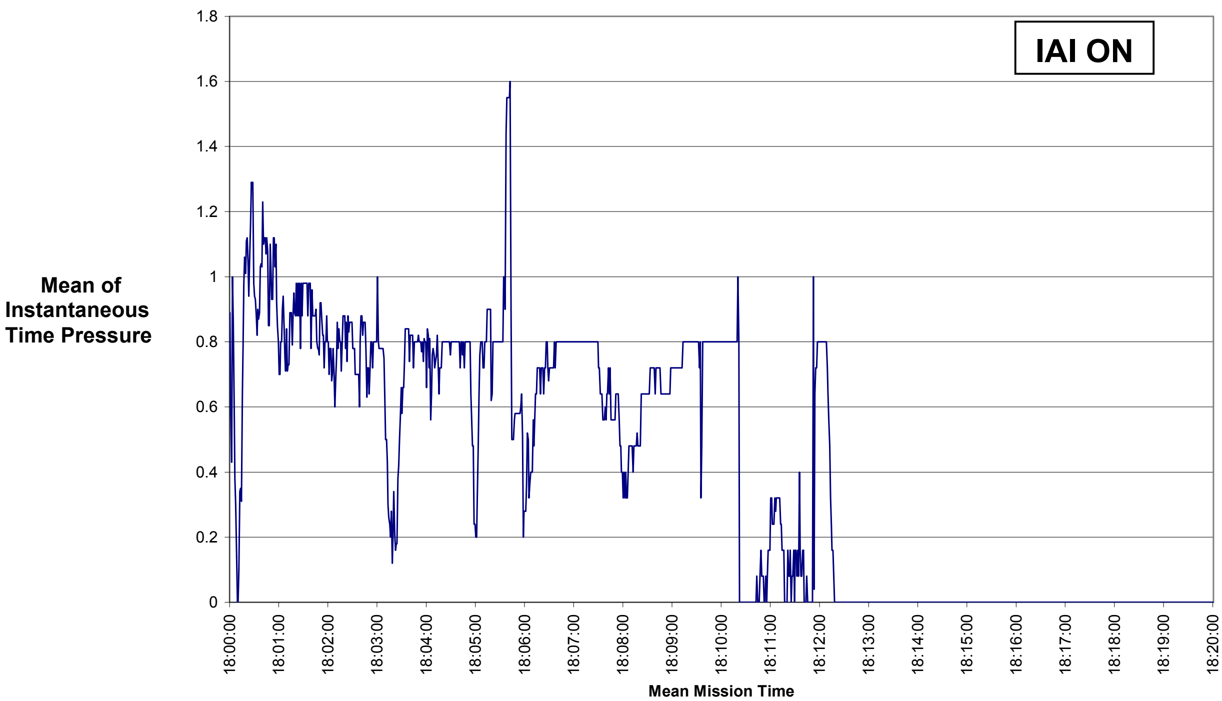
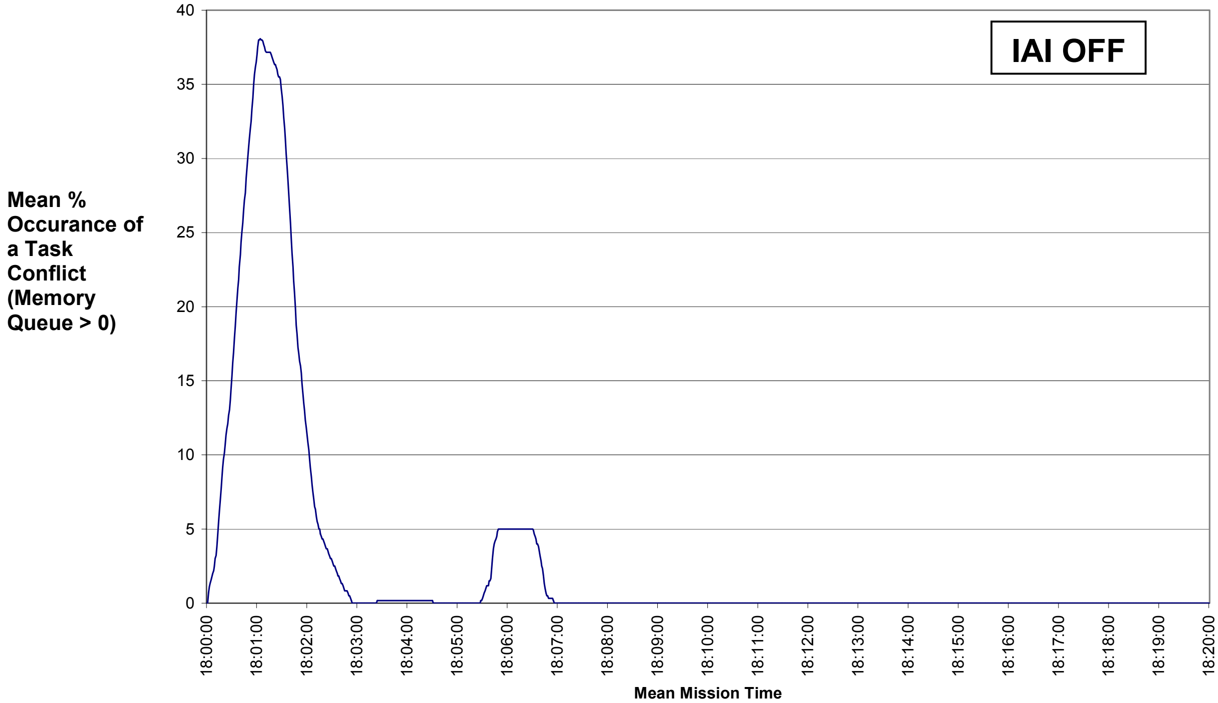


Figure 3 Scenario Part 1 – Mean of Instantaneous Time Pressure (TACNAV)



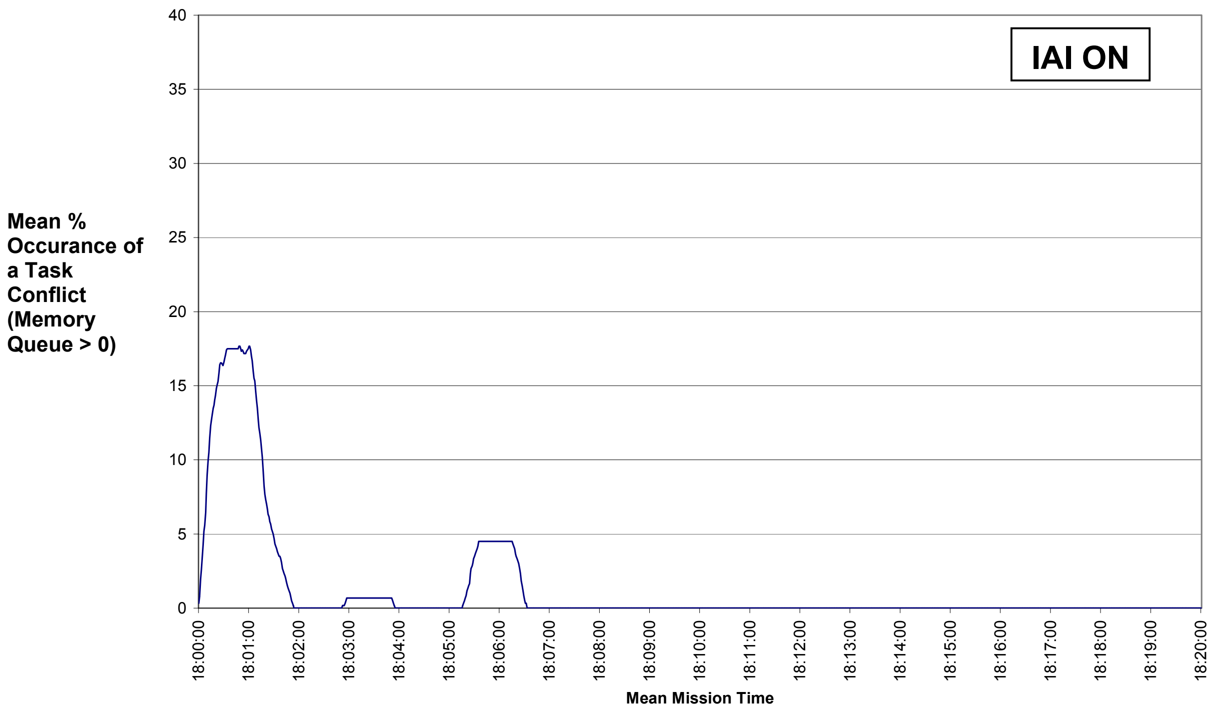
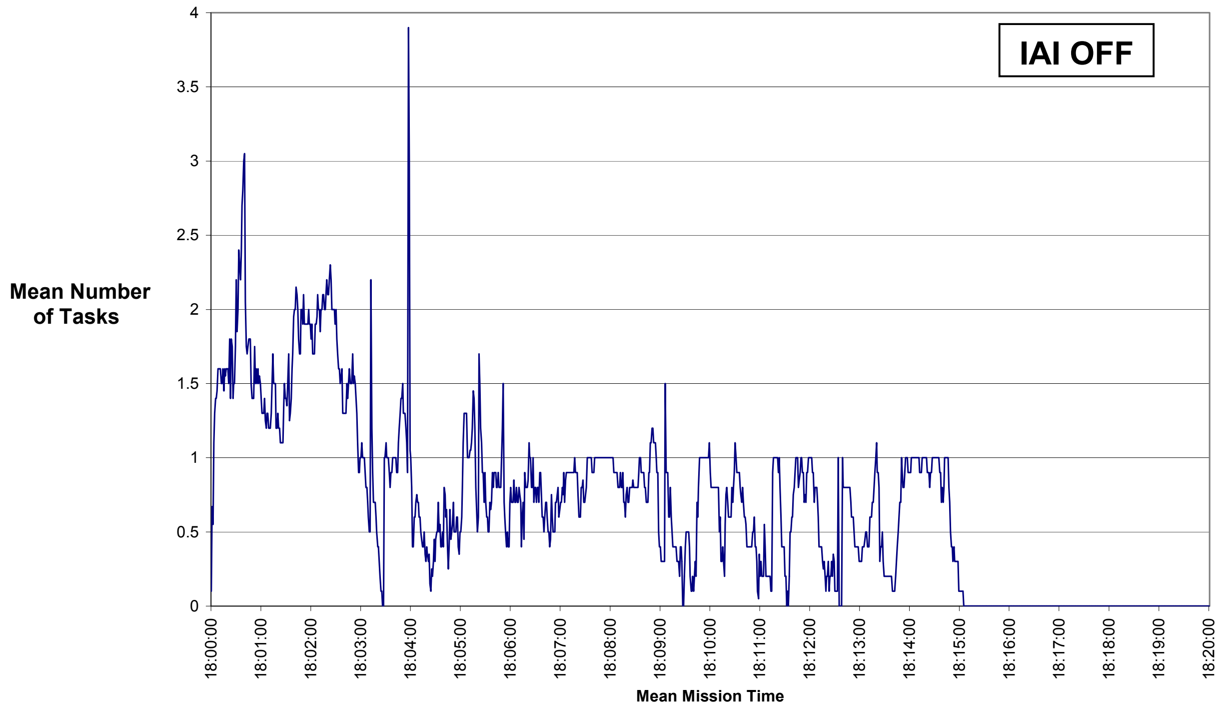


Figure 4 Scenario Part 1 – Task Conflict Parameter (UAV Operator)



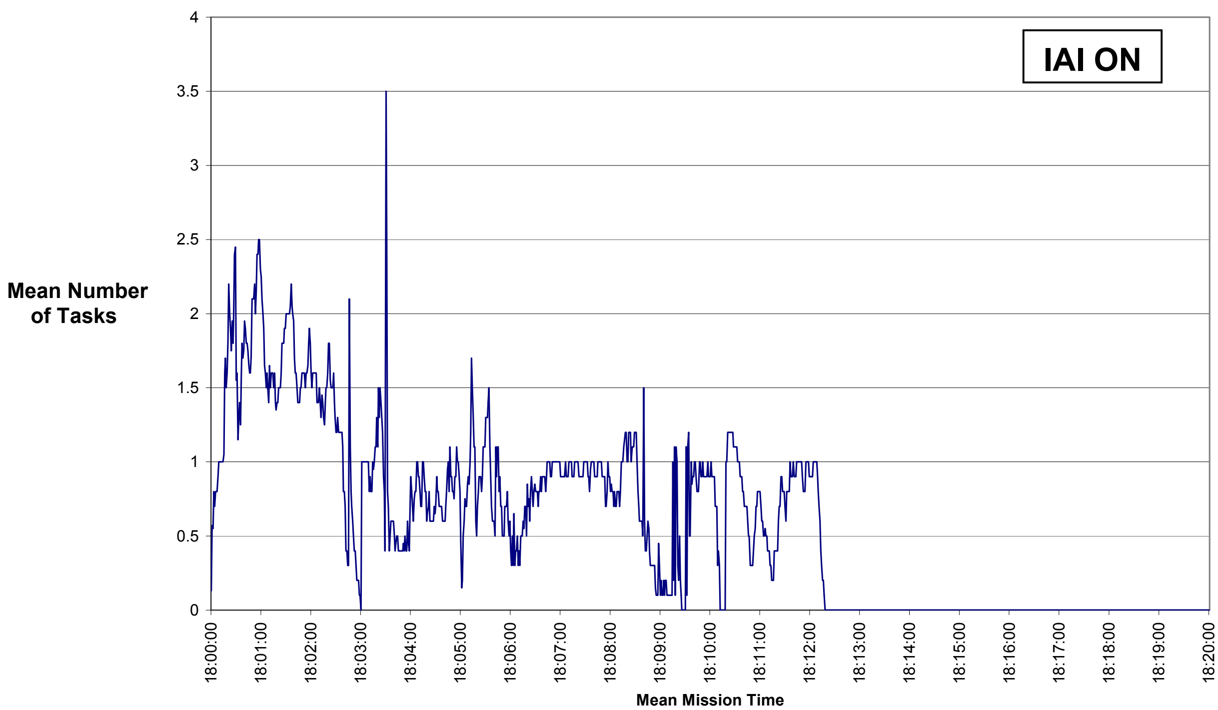
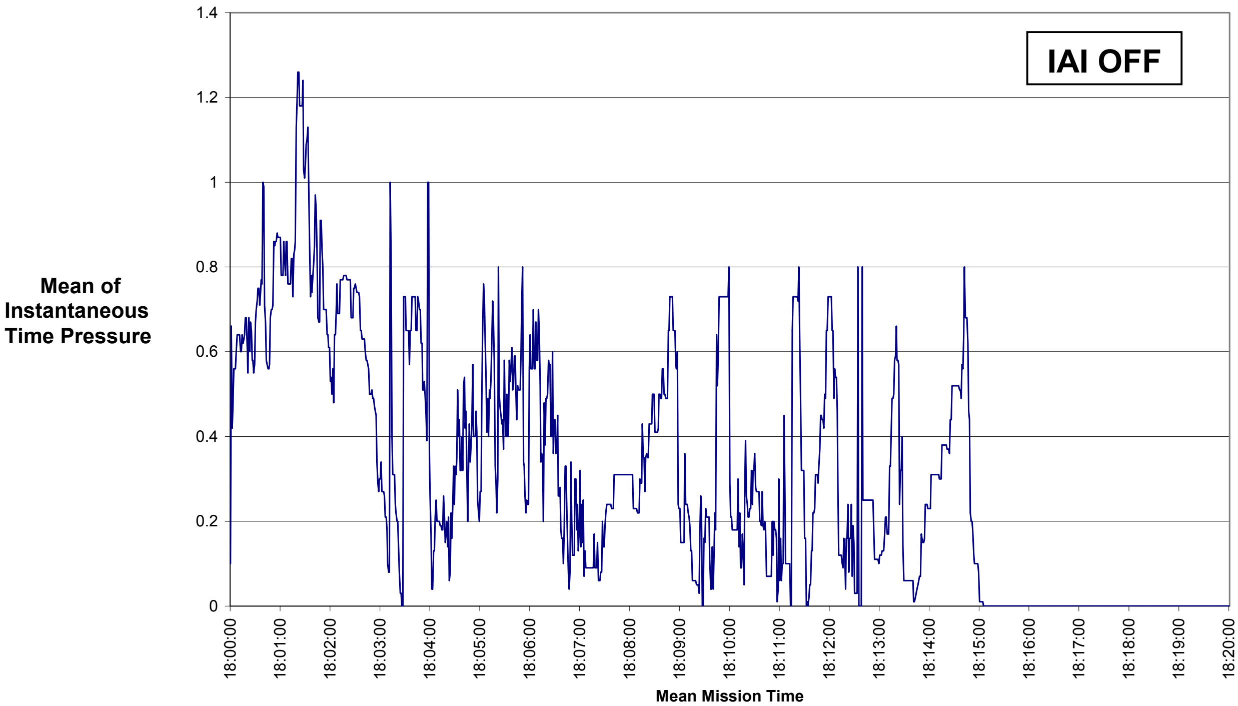


Figure 5 Scenario Part 1 – Number of Ongoing Tasks (UAV Operator)



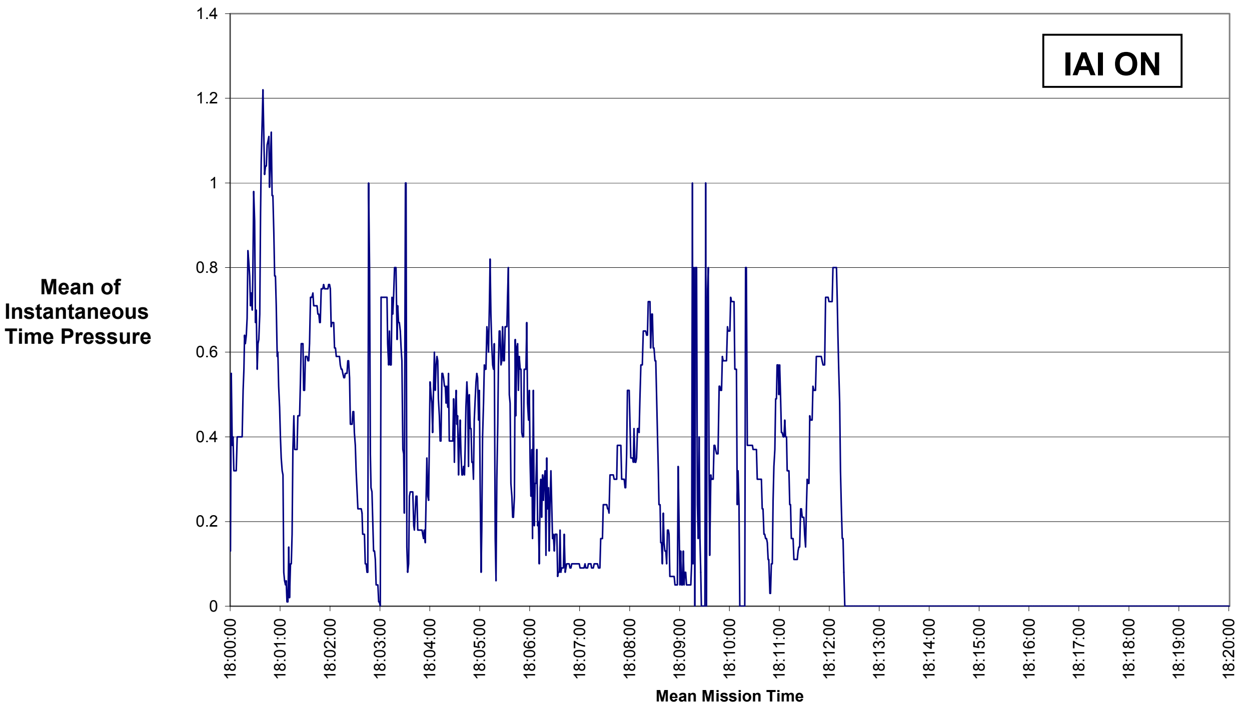


Figure 6 Scenario Part 1 – Mean of Instantaneous Time Pressure (UAV Operator)

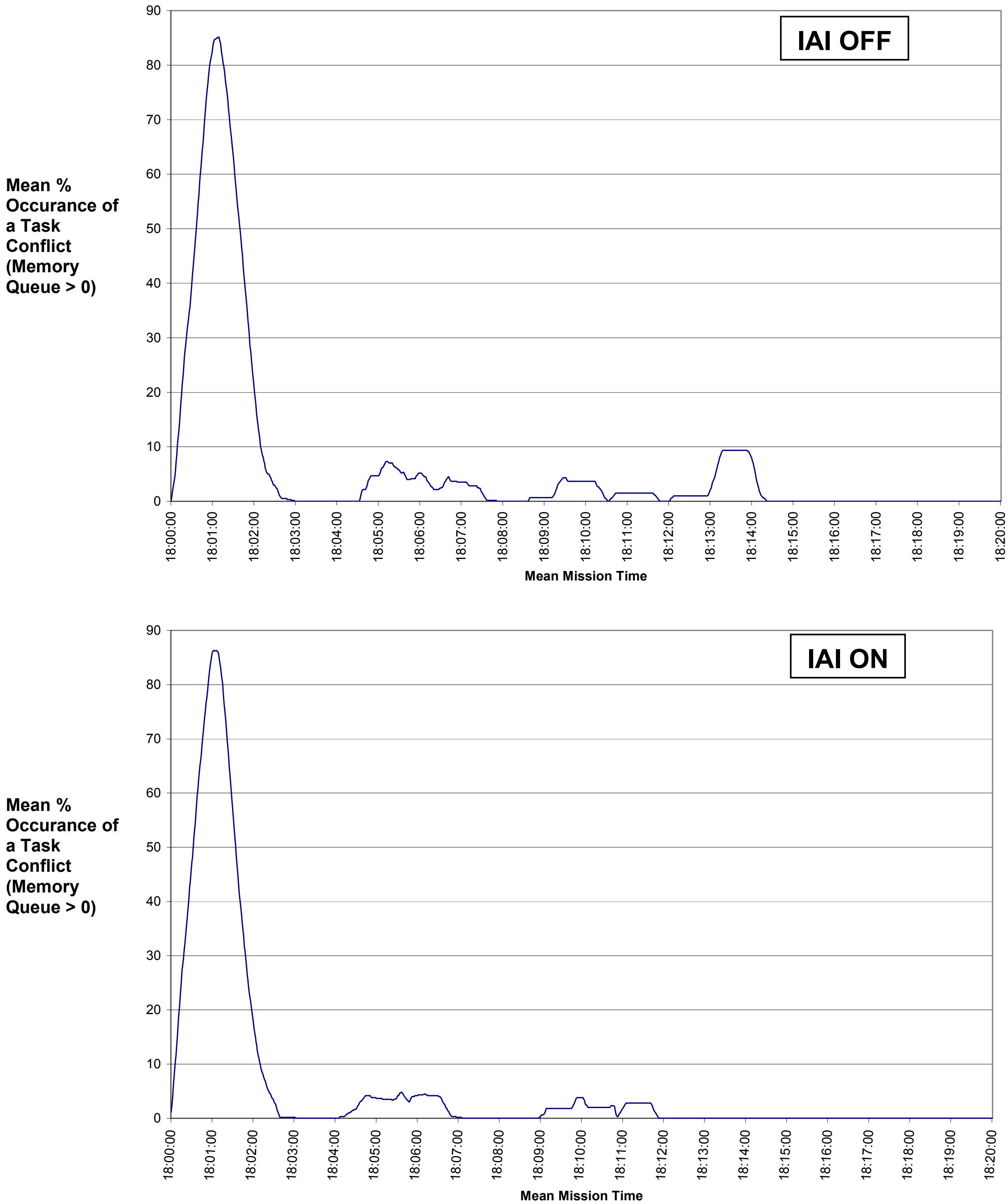
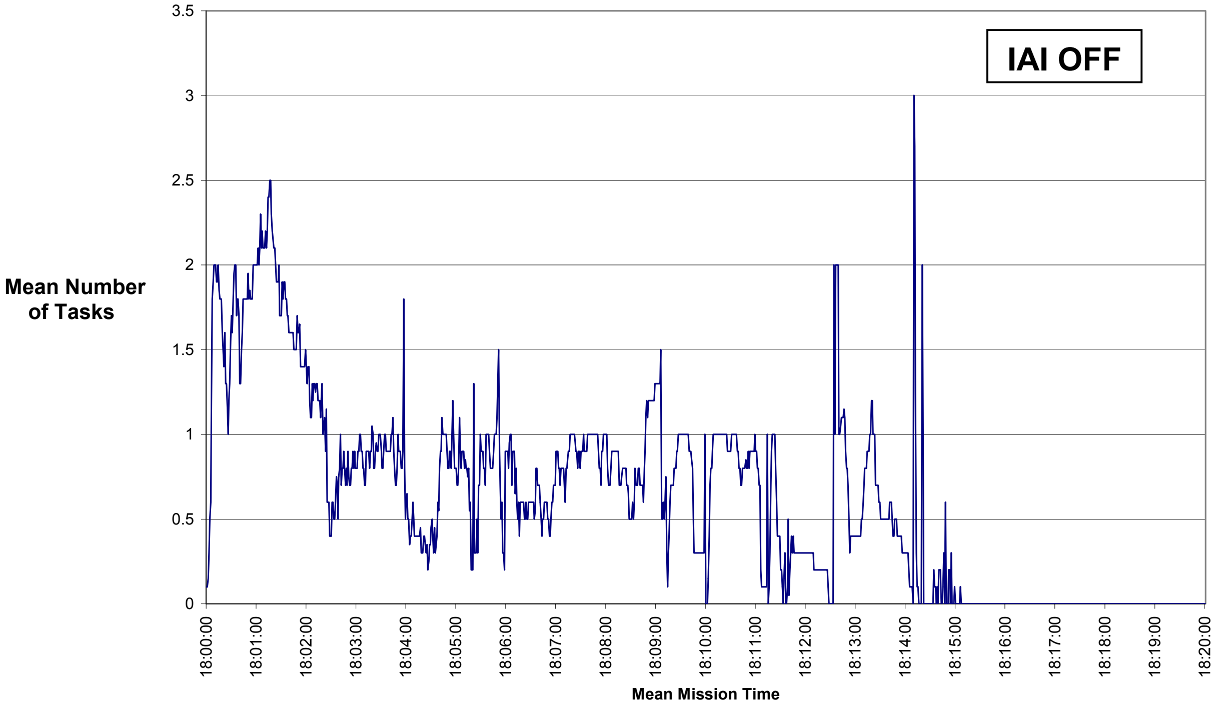


Figure 7 Scenario Part 1 – Task Conflict Parameter (UAV Pilot)



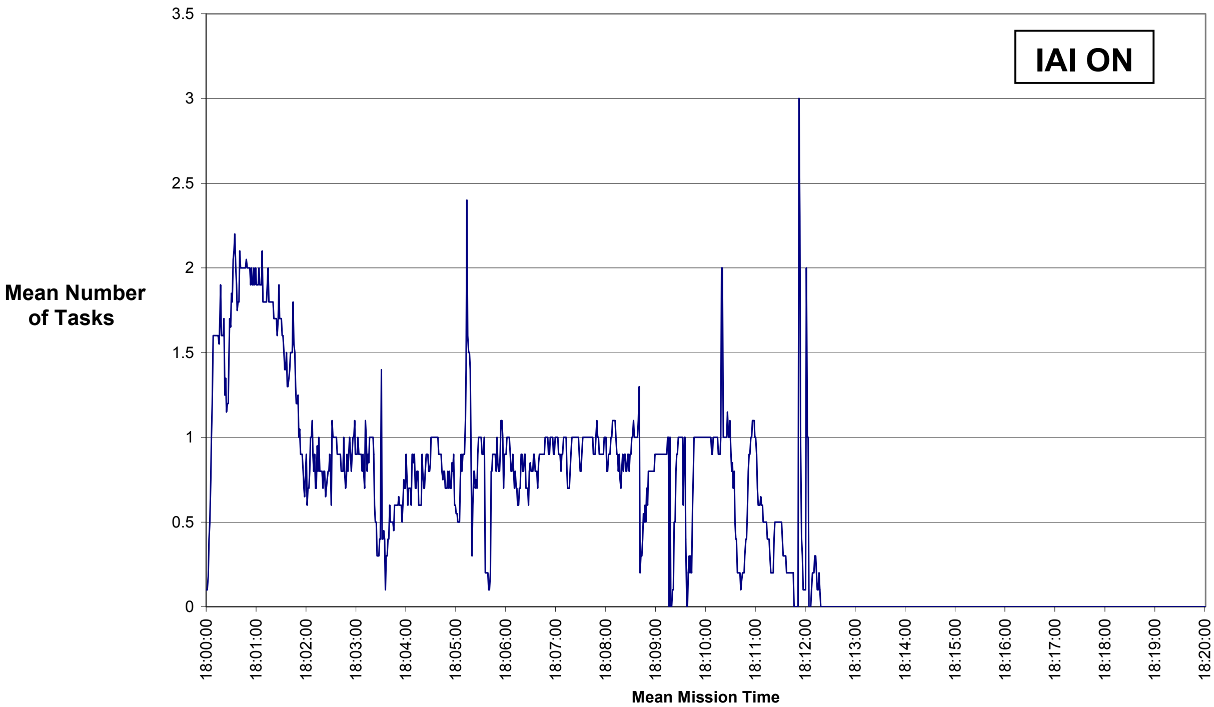
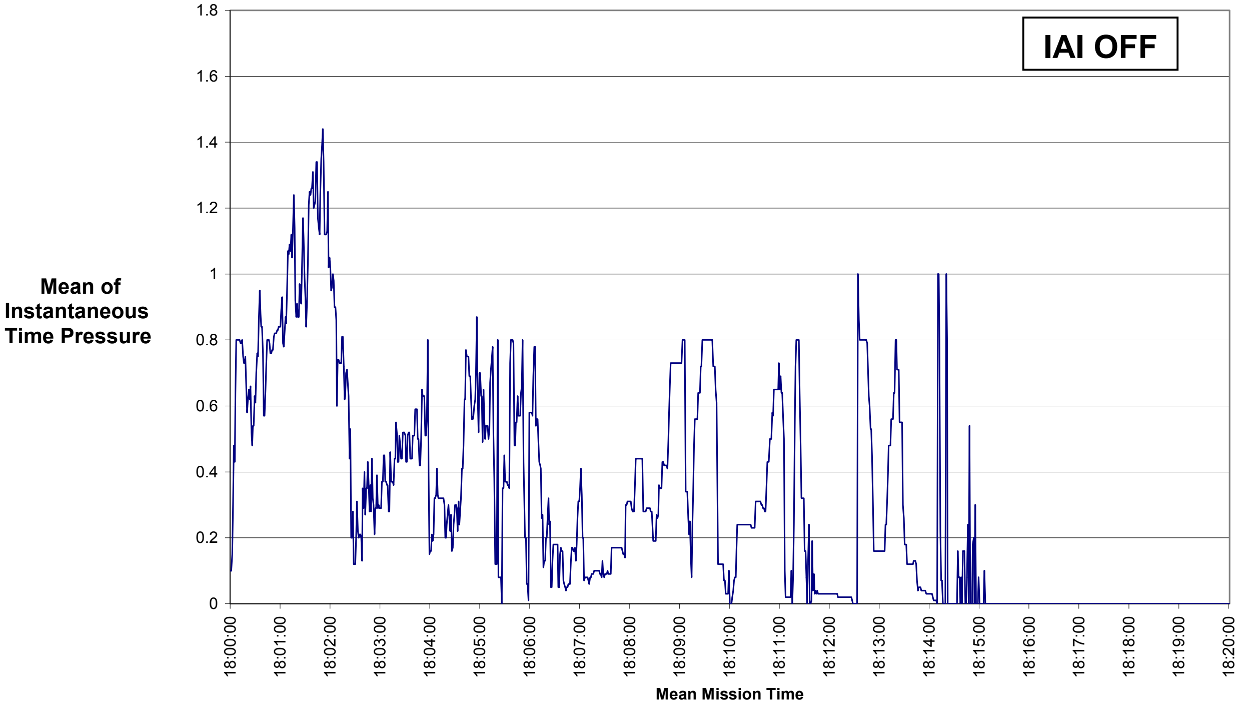


Figure 8 Scenario Part 1 – Number of Ongoing Tasks (UAV Pilot)



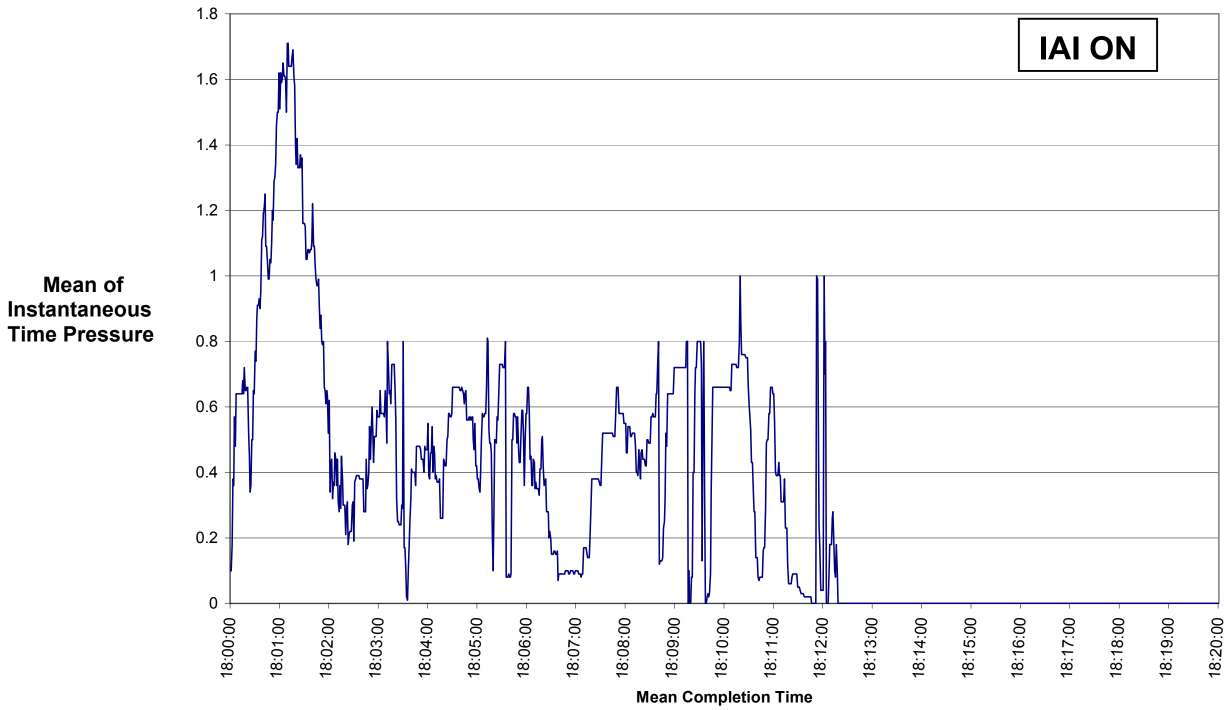
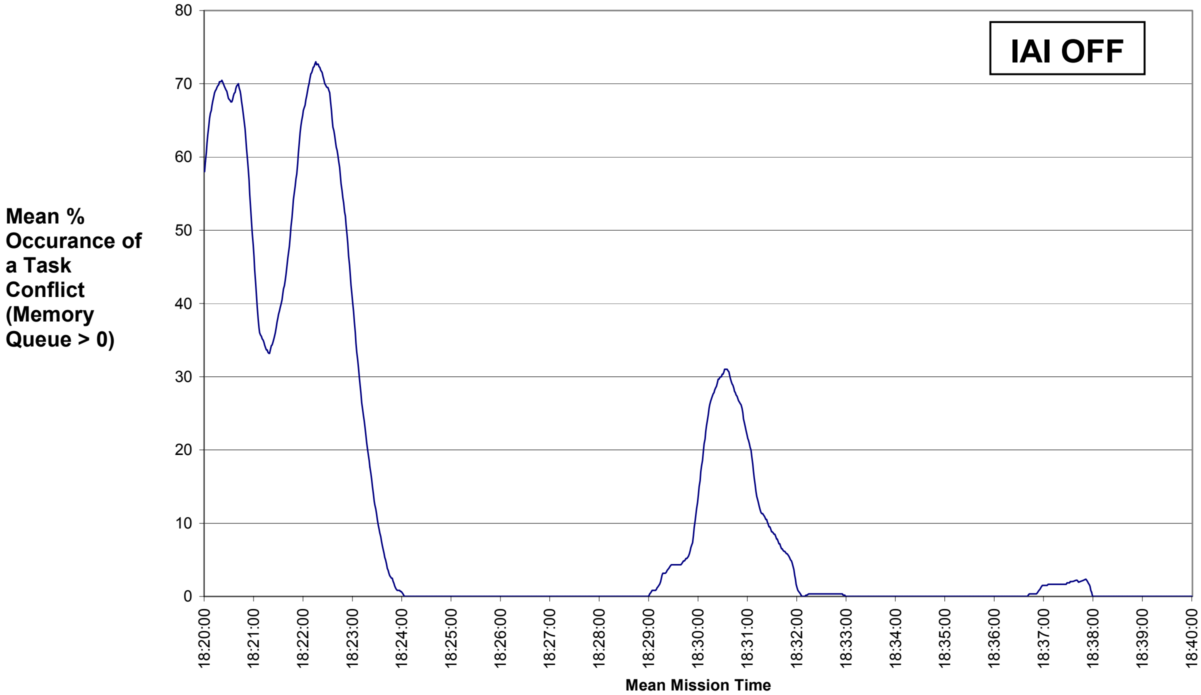


Figure 9 Scenario Part 1 – Mean of Instantaneous Time Pressure (UAV Pilot)



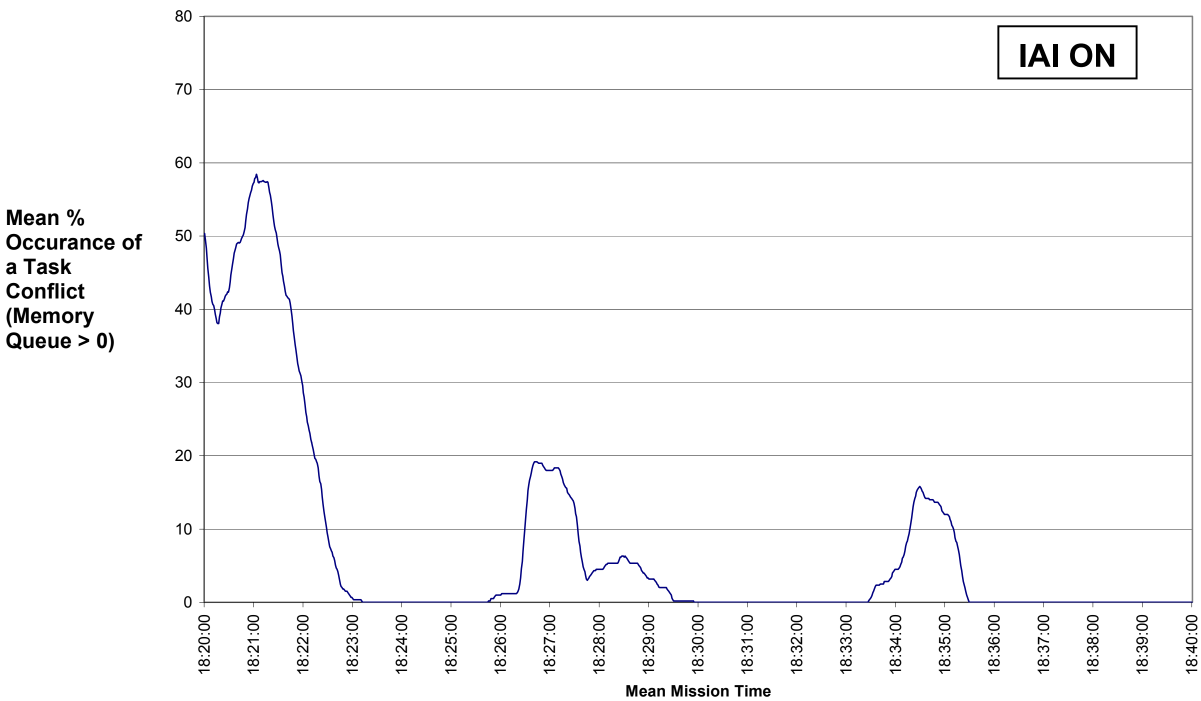


Figure 10 Scenario Part 2 – Task Conflict Parameter (TACNAV)

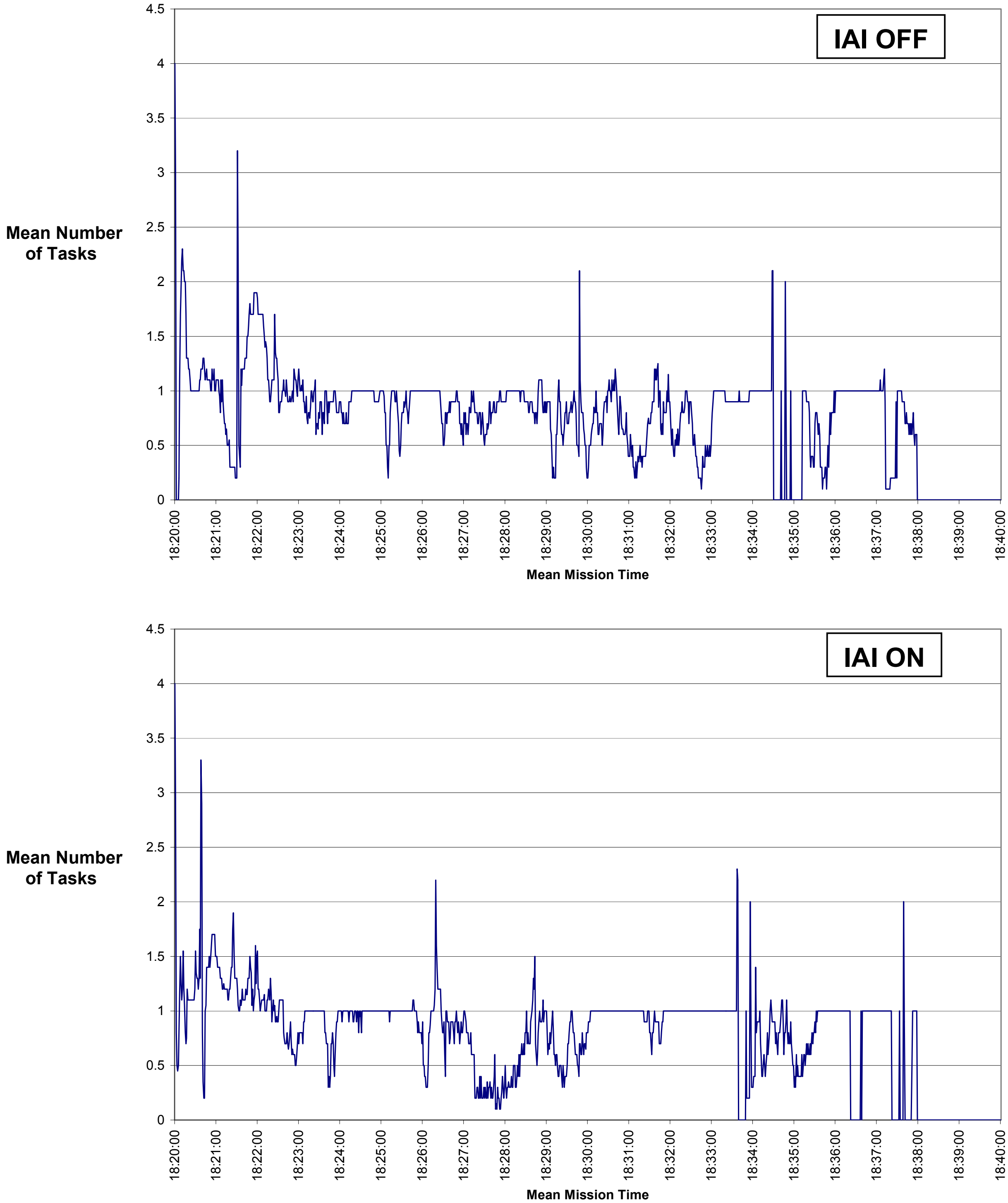


Figure 11 Scenario Part 2 – Number of Ongoing Tasks (TACNAV)

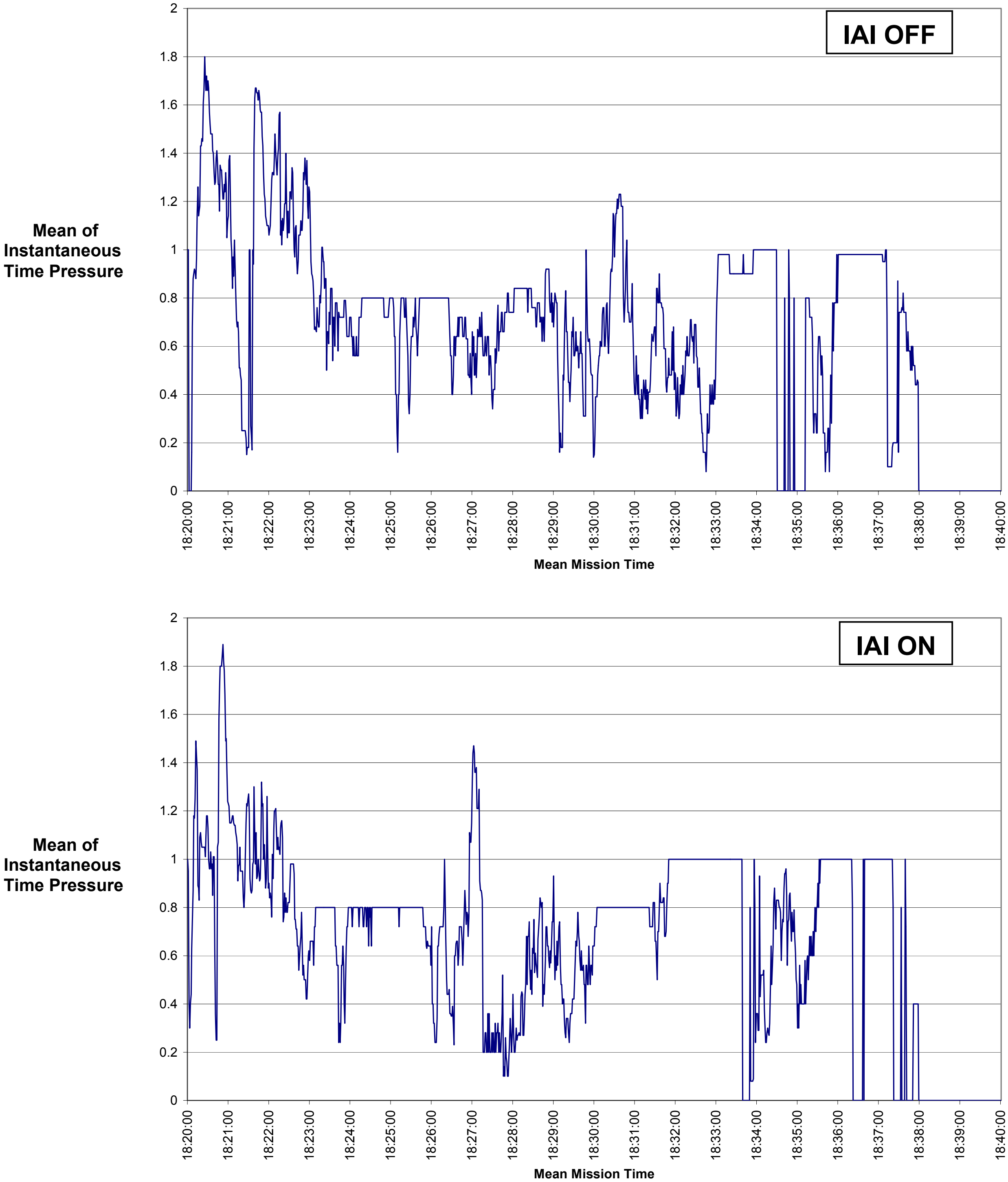


Figure 12 Scenario Part 2 – Mean of Instantaneous Time Pressure (TACNAV)

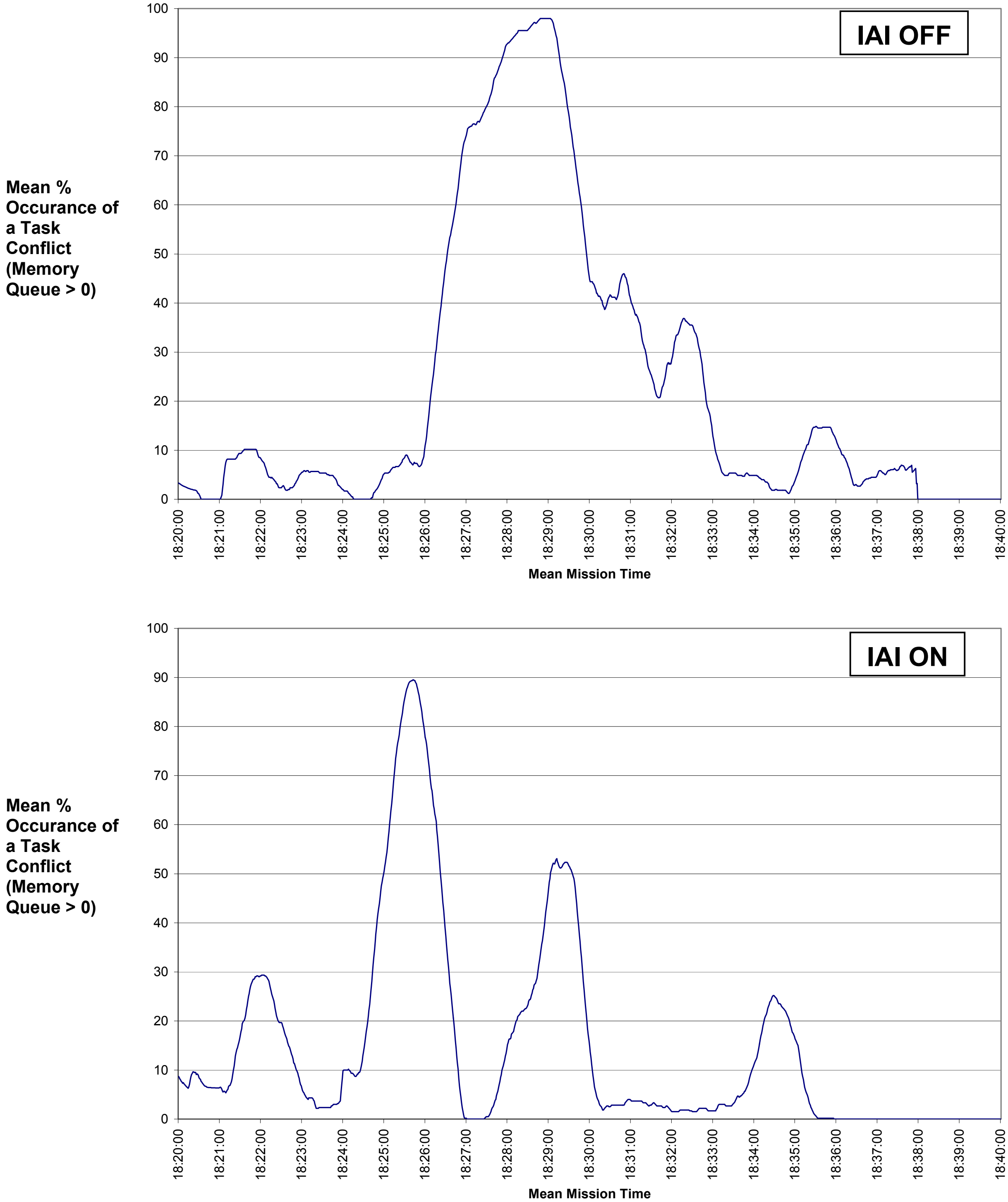
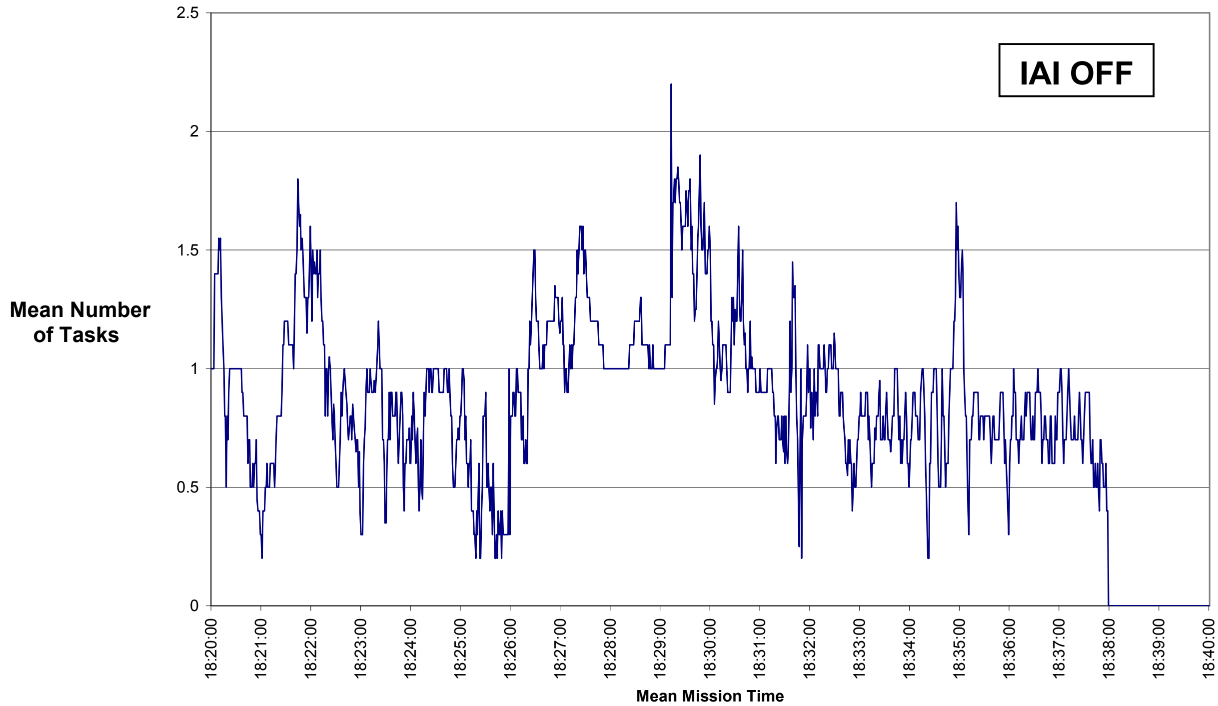


Figure 13 Scenario Part 2 – Task Conflict Parameter (UAV Operator)



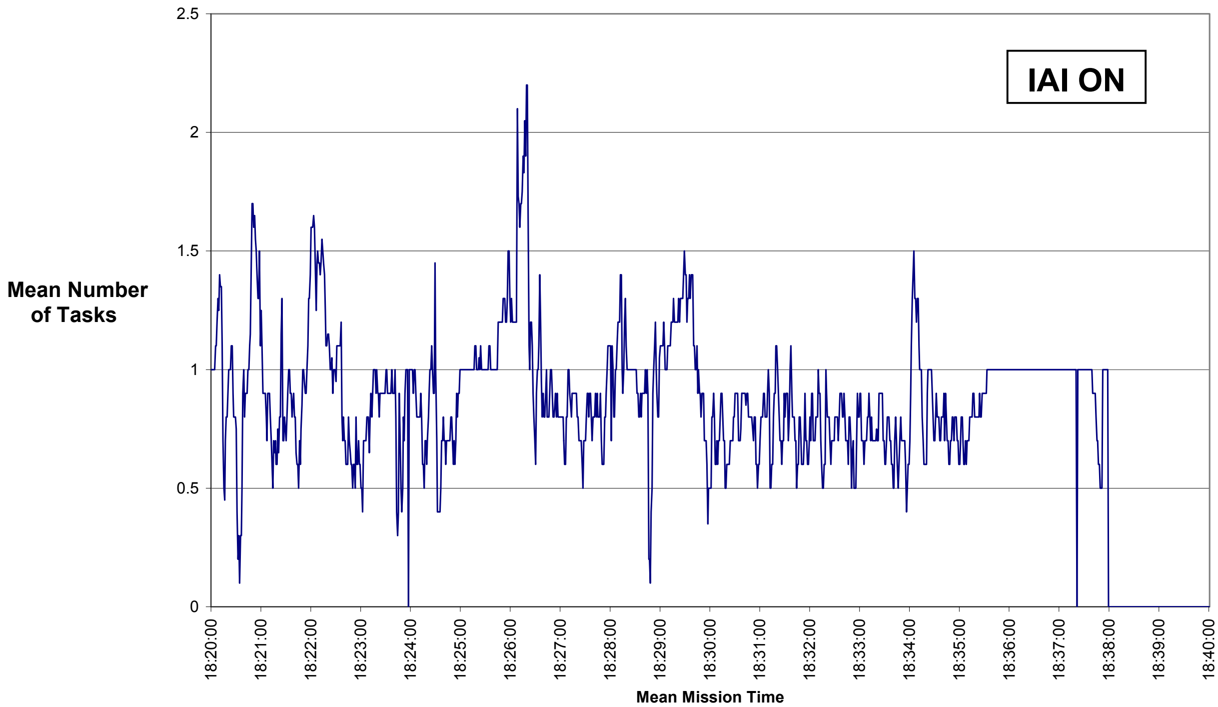
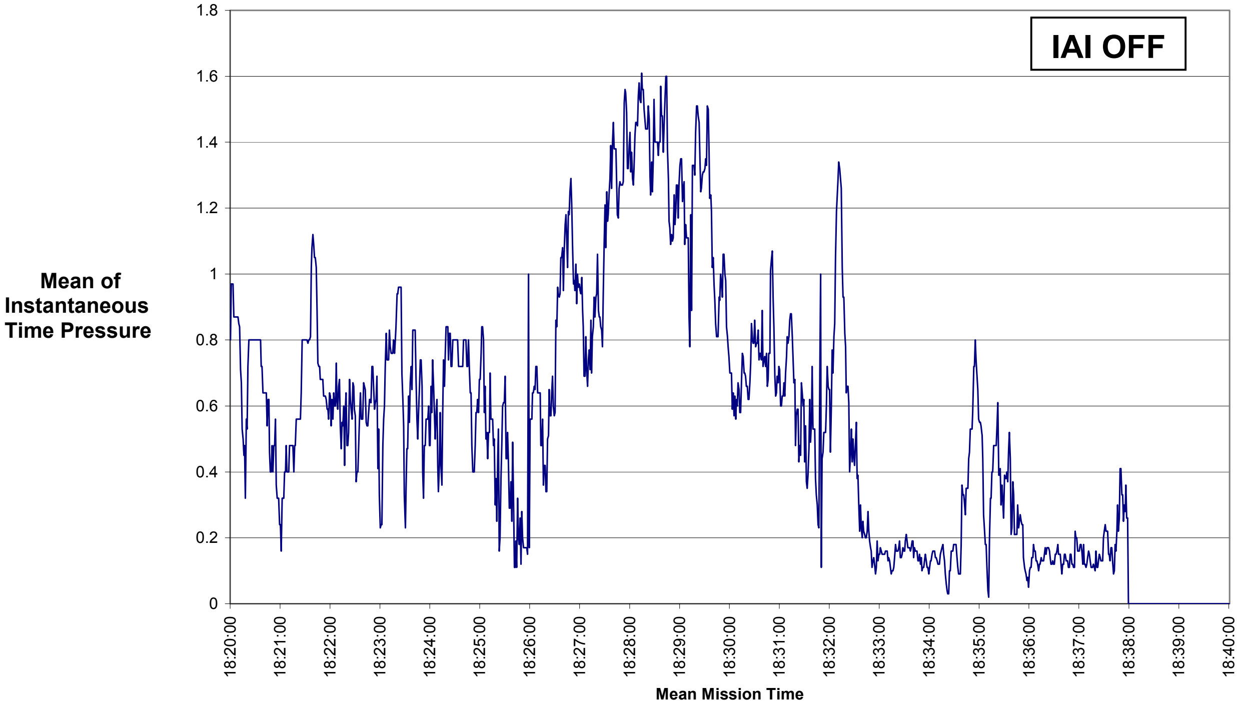


Figure 14 Scenario Part 2 – Number of Ongoing Tasks (UAV Operator)



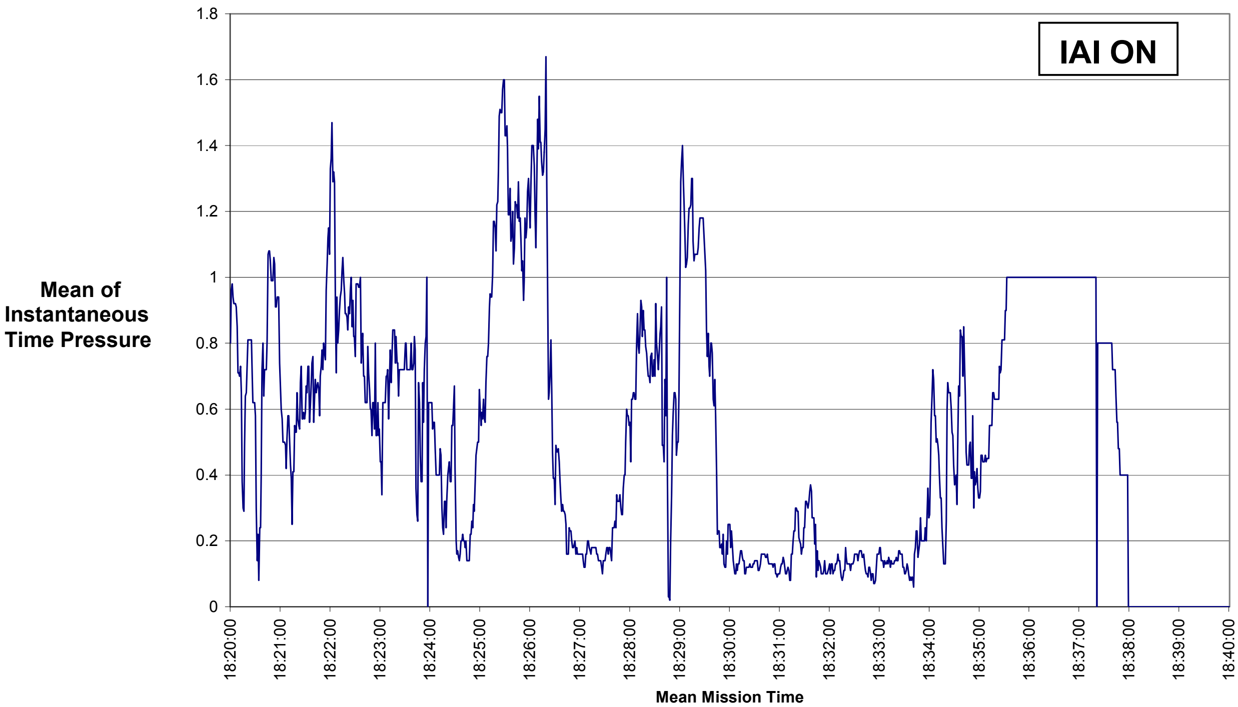
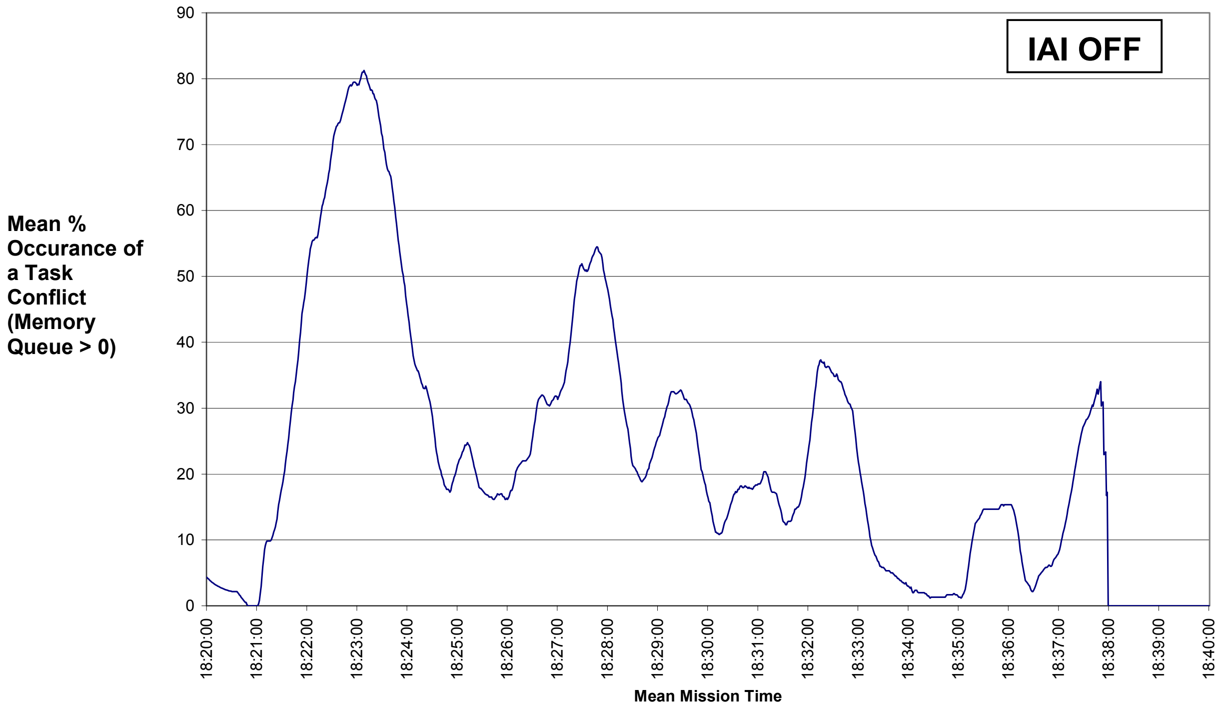


Figure 15 Scenario Part 2 – Mean of Instantaneous Time Pressure (UAV Operator)



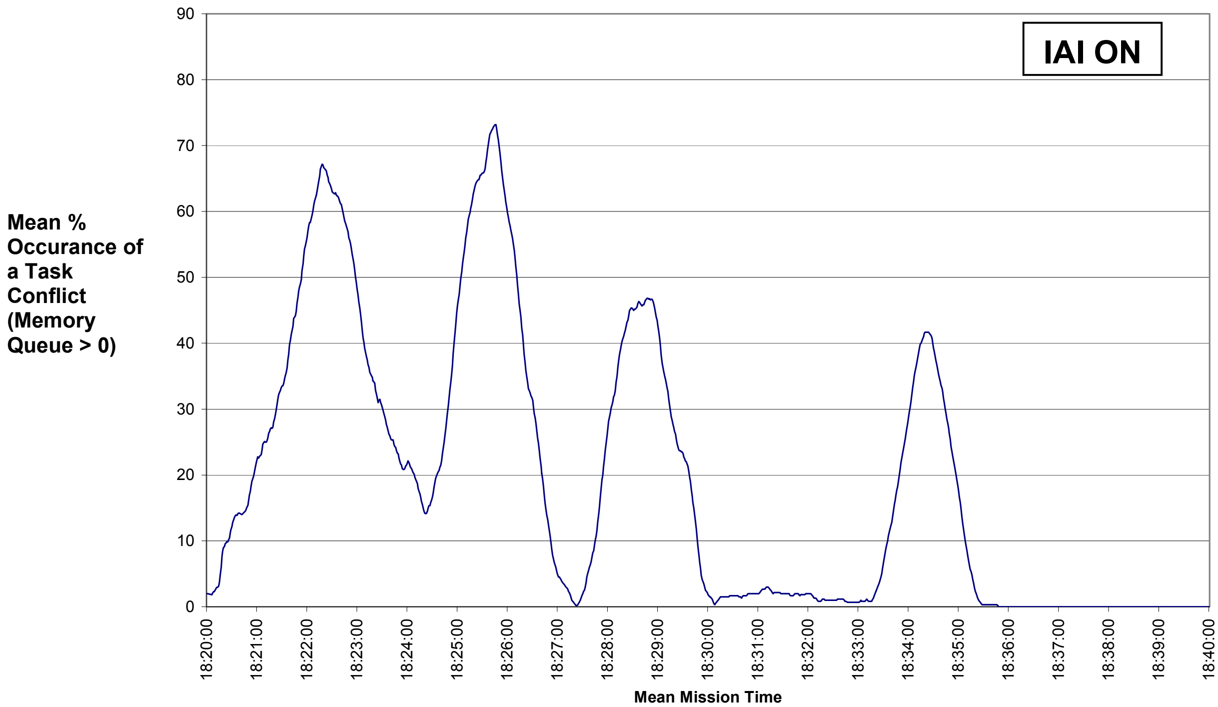


Figure 16 Scenario Part 2 – Task Conflict Parameter (UAV Pilot)

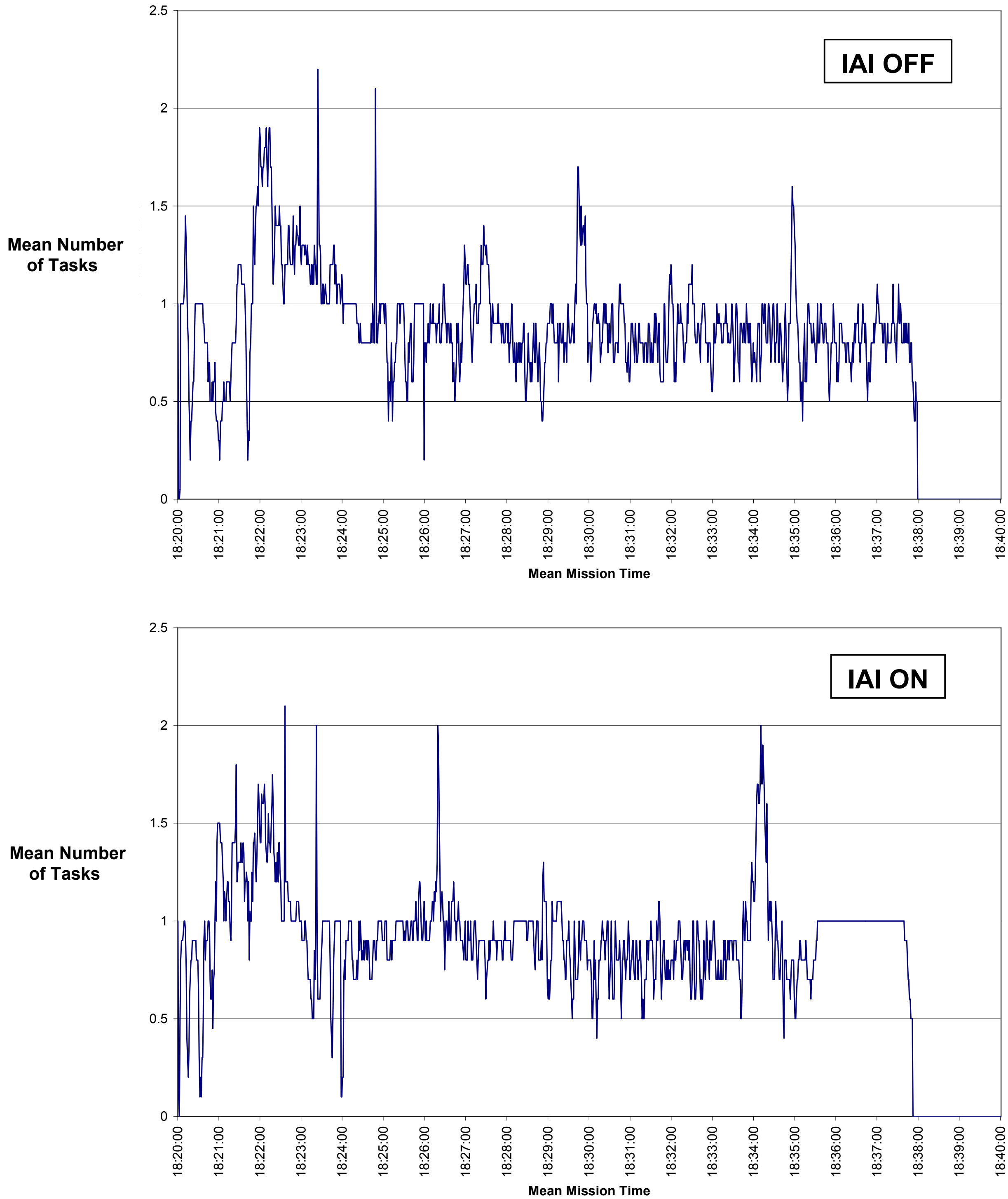


Figure 17 Scenario Part 2 – Number of Ongoing Tasks (UAV Pilot)

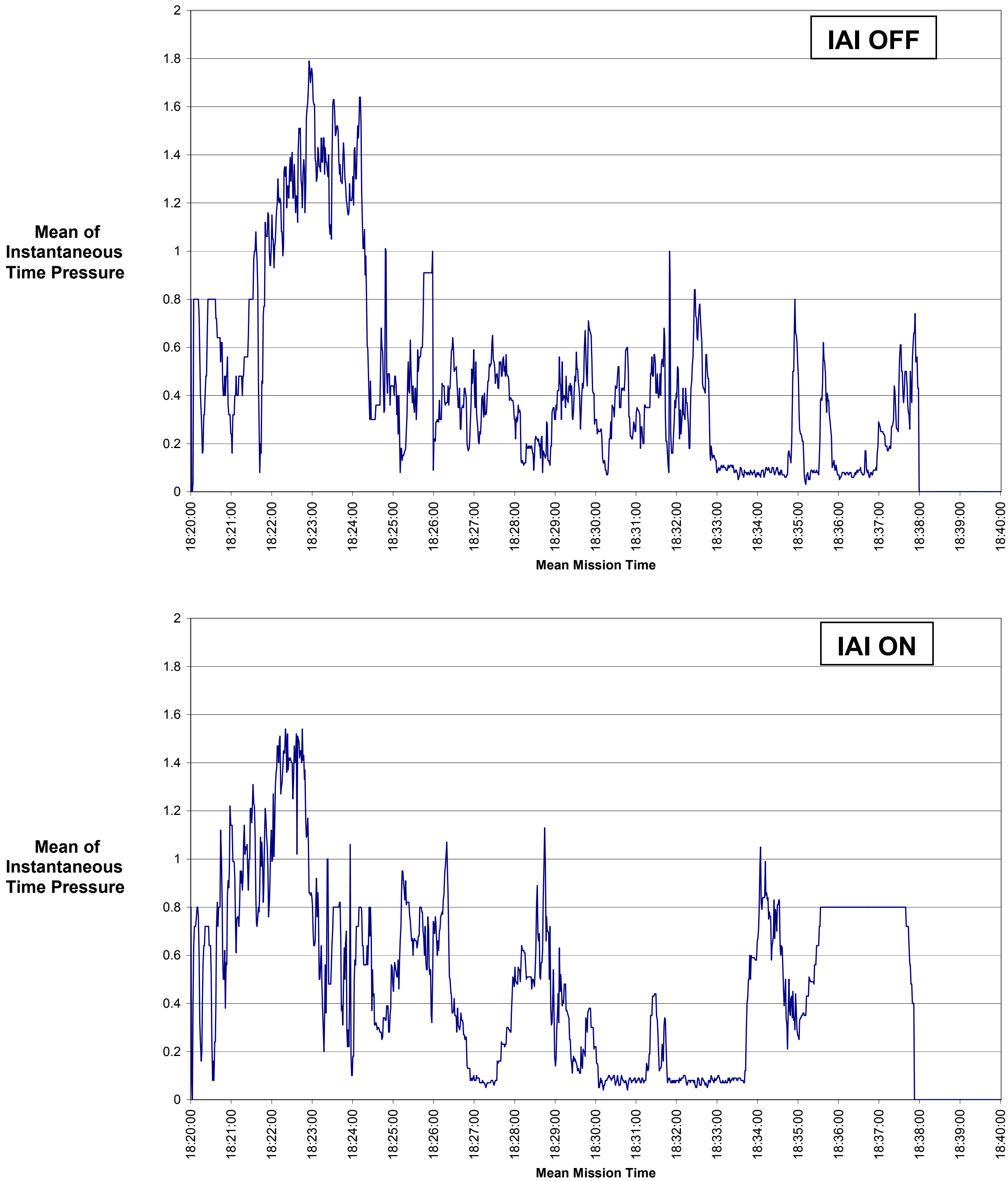
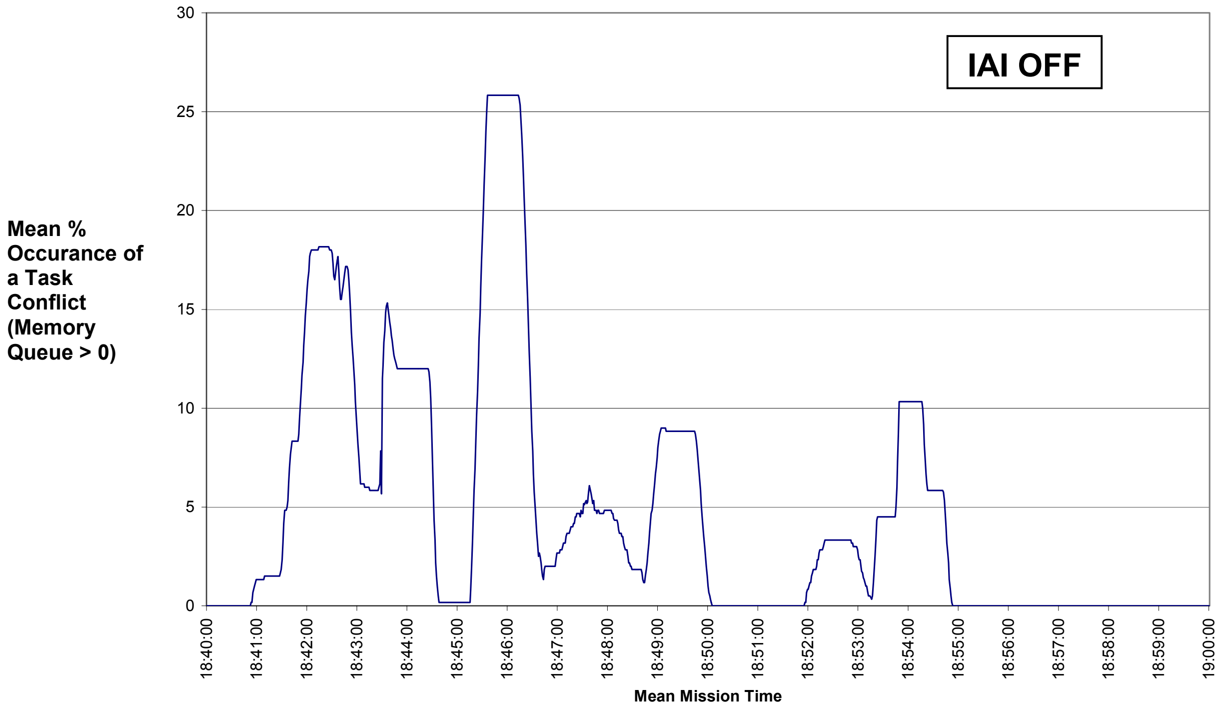


Figure 18 Scenario Part 2 – Mean of Instantaneous Time Pressure (UAV Pilot)



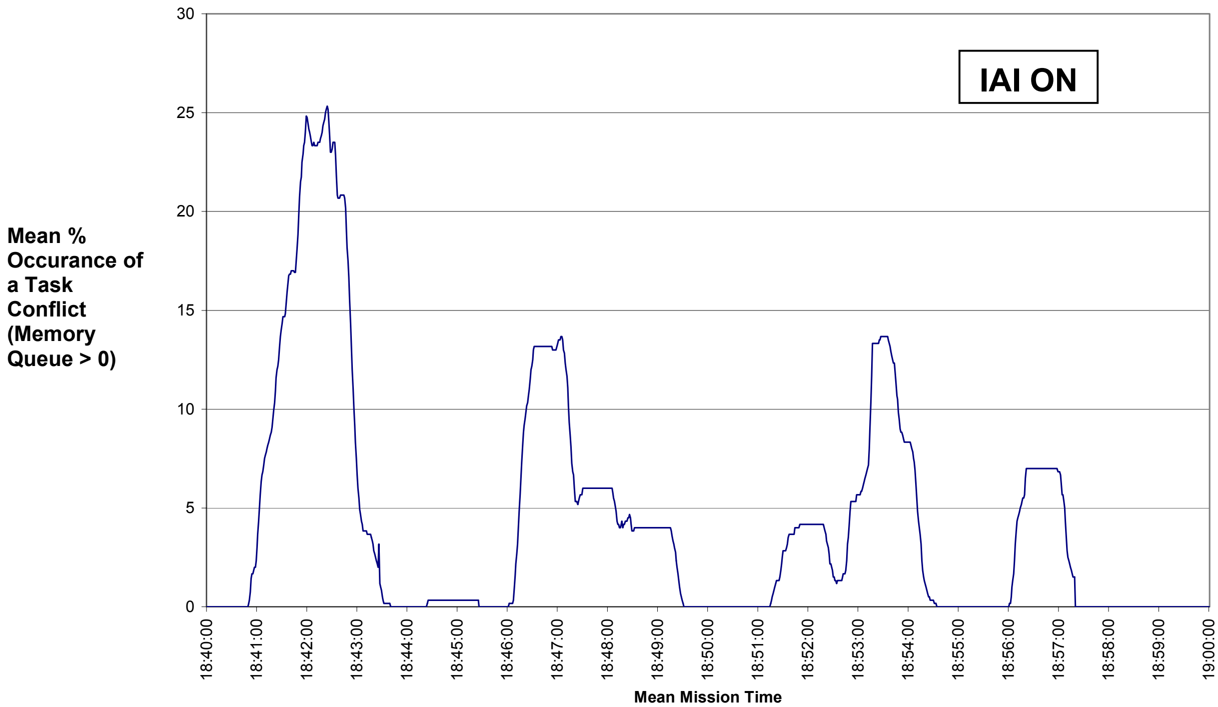
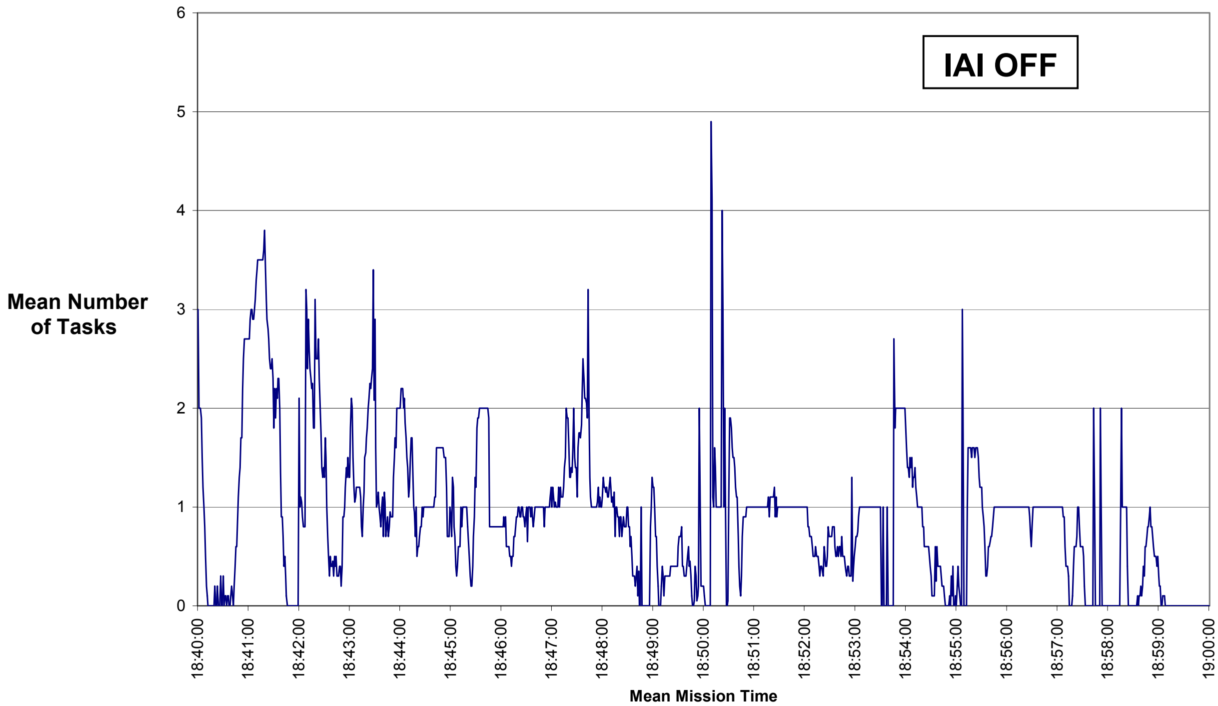


Figure 19 Scenario Part 3 – Task Conflict Parameter (TACNAV)



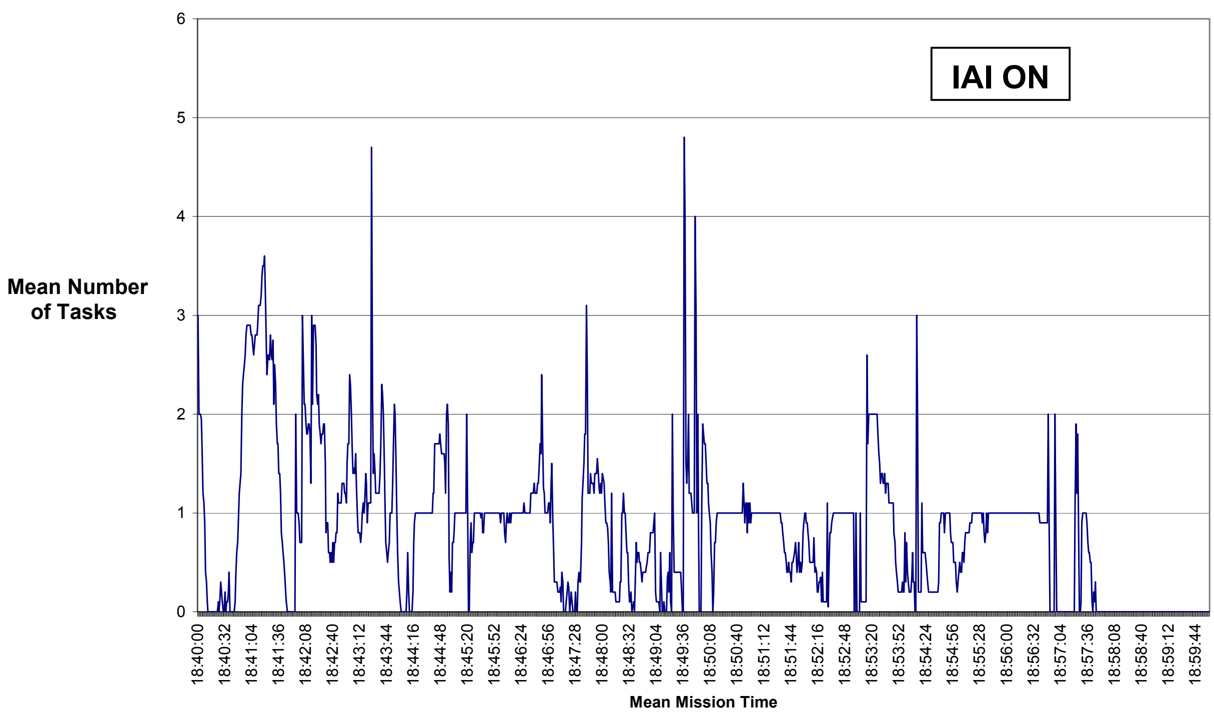
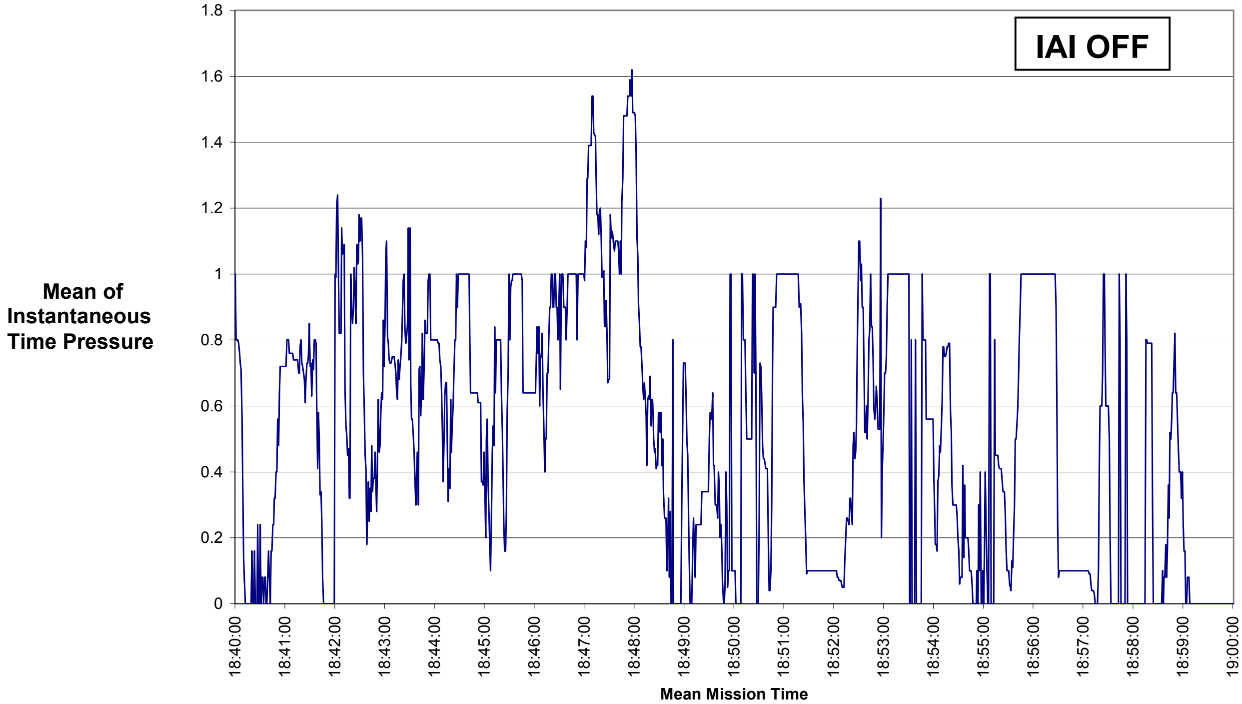


Figure 20 Scenario Part 3 – Number of Ongoing Tasks (TACNAV)



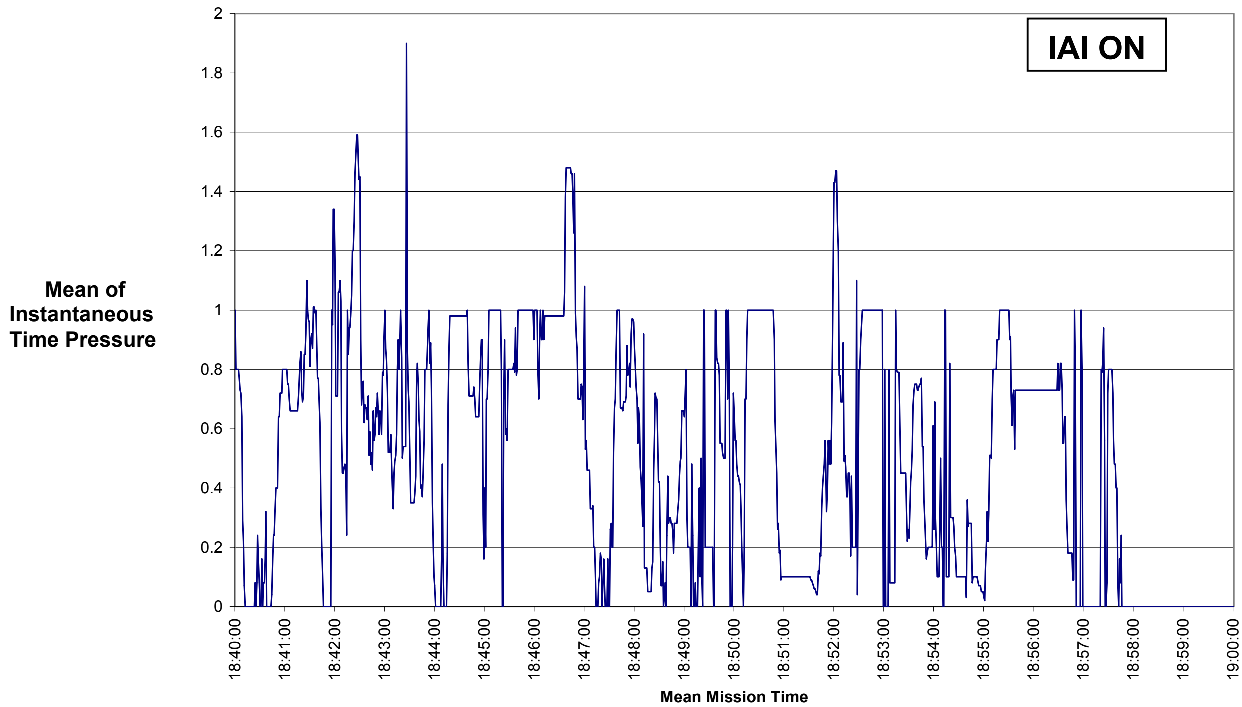
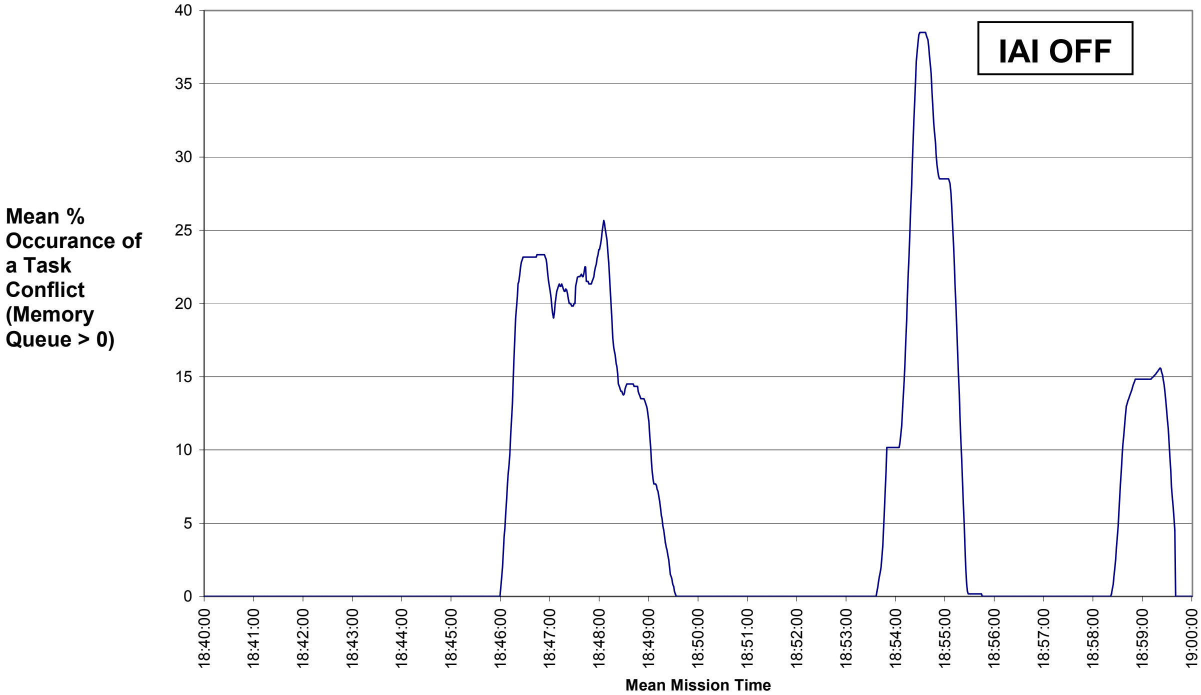


Figure 21 Scenario Part 3 – Mean of Instantaneous Time Pressure (TACNAV)



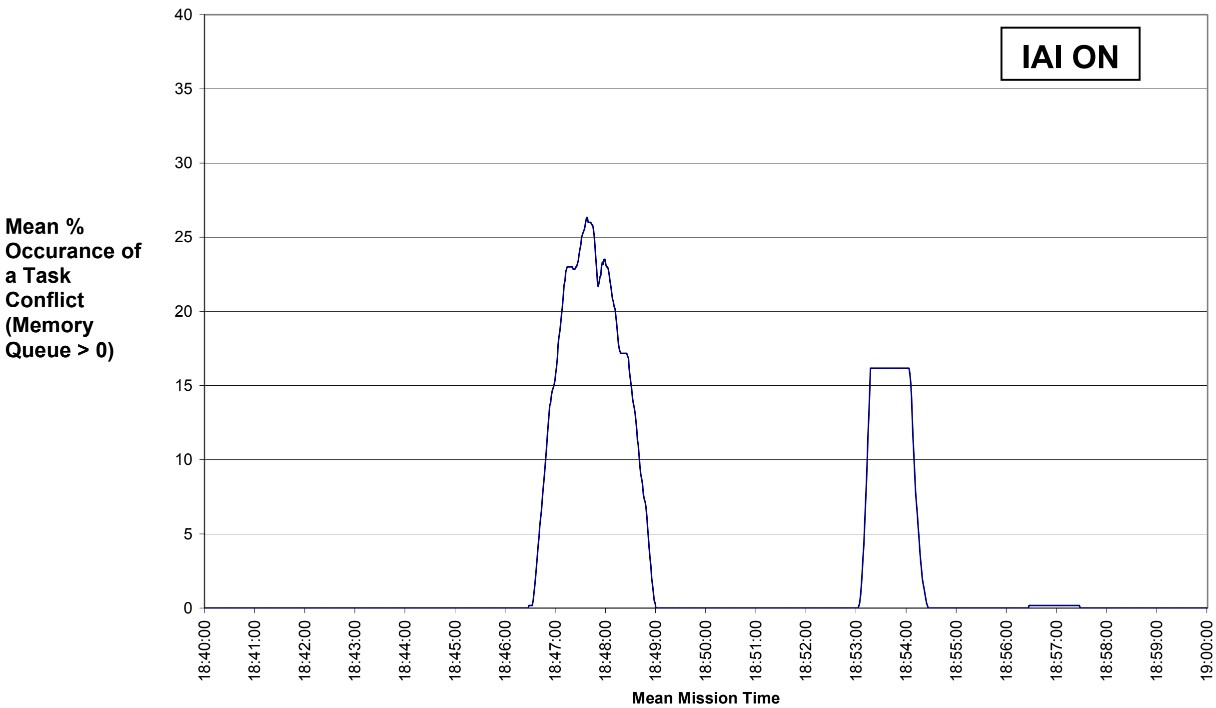


Figure 22 Scenario Part 3 – Task Conflict Parameter (UAV Operator)

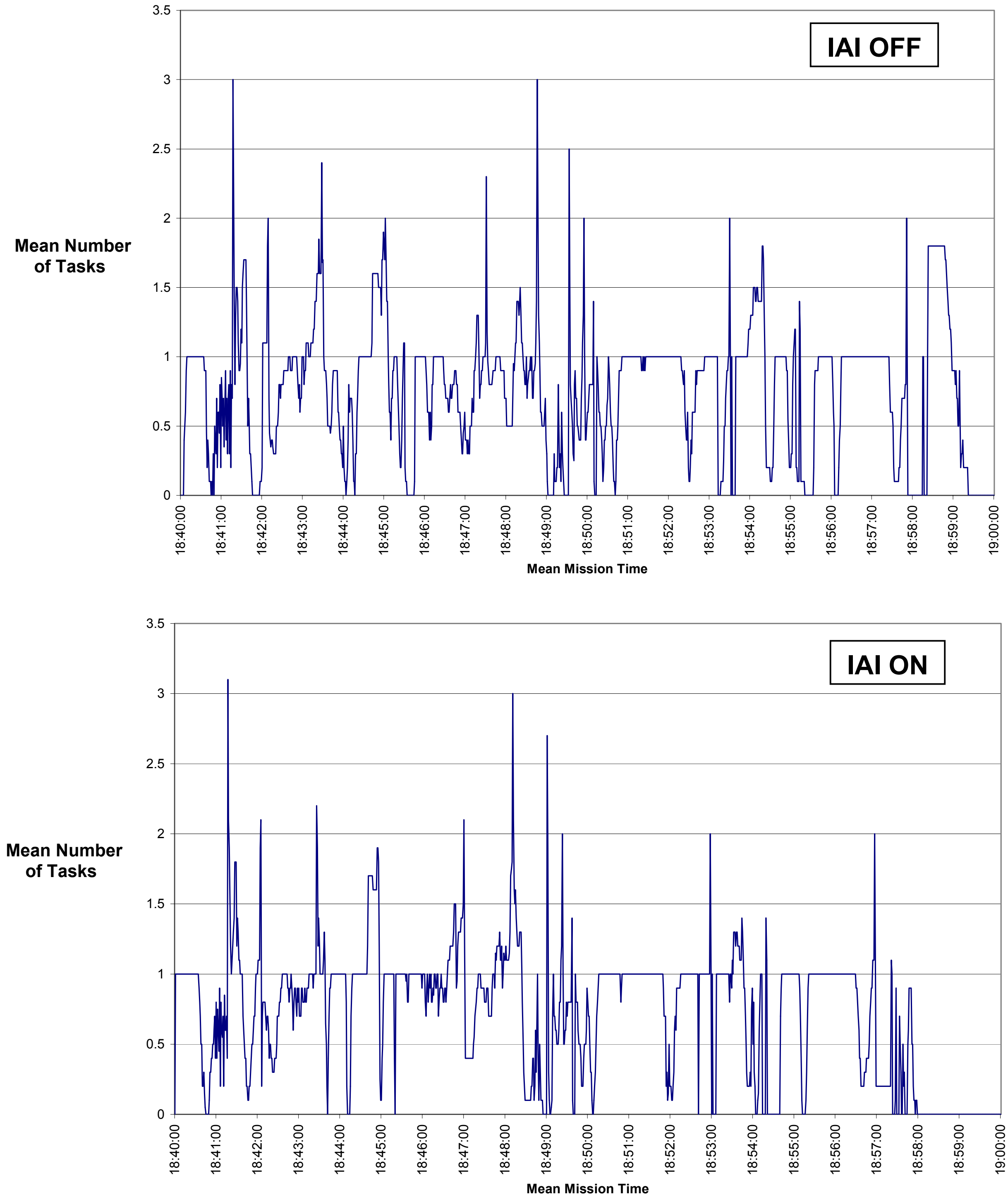
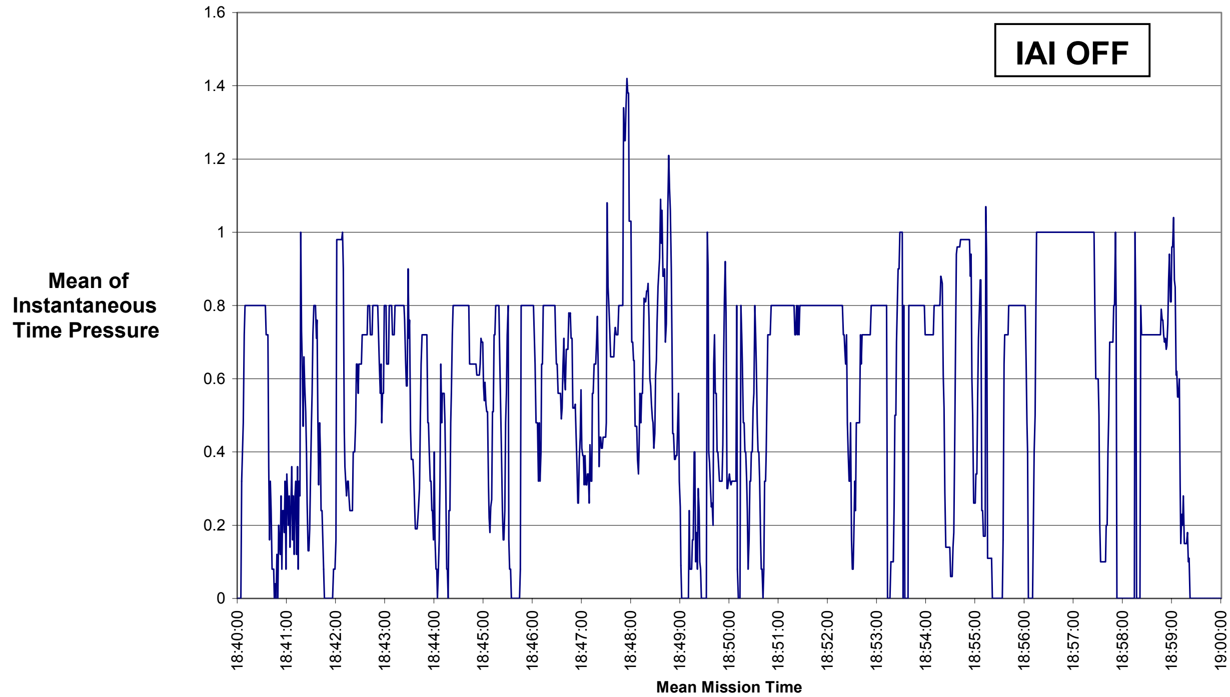


Figure 23 Scenario Part 3 – Number of Ongoing Tasks (UAV Operator)



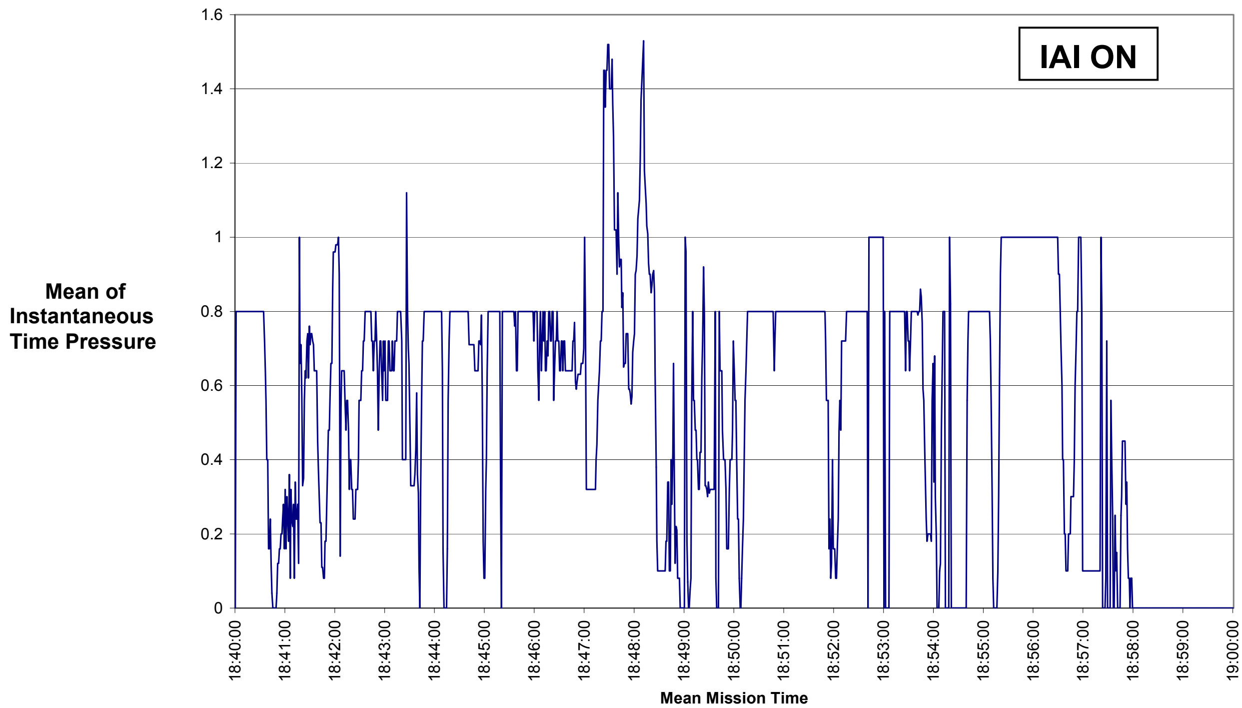
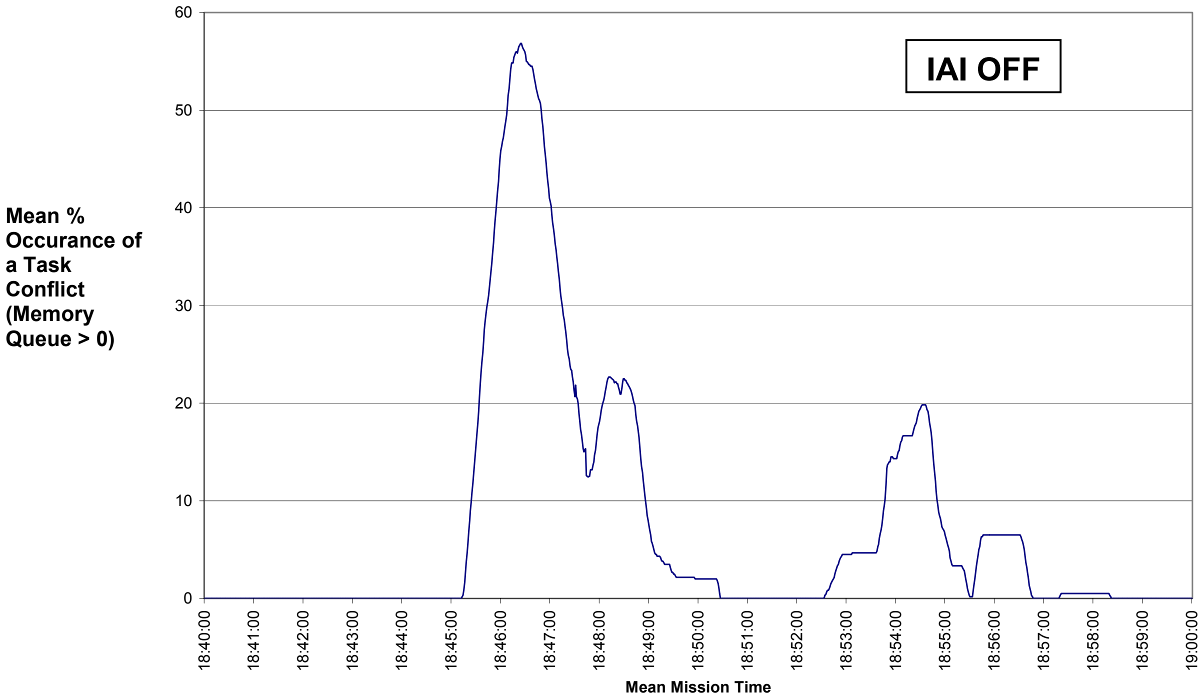


Figure 24 Scenario Part 3 – Mean of Instantaneous Time Pressure (UAV Operator)



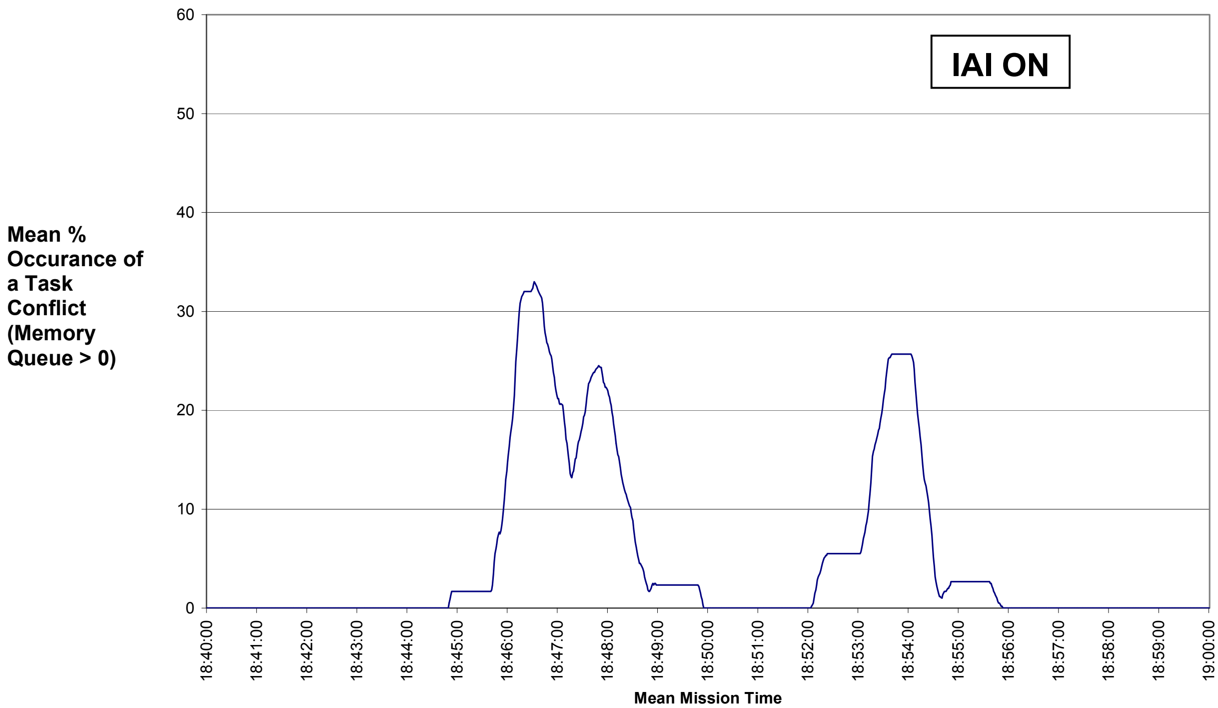


Figure 25 Scenario Part 3 – Task Conflict Parameter (UAV Pilot)

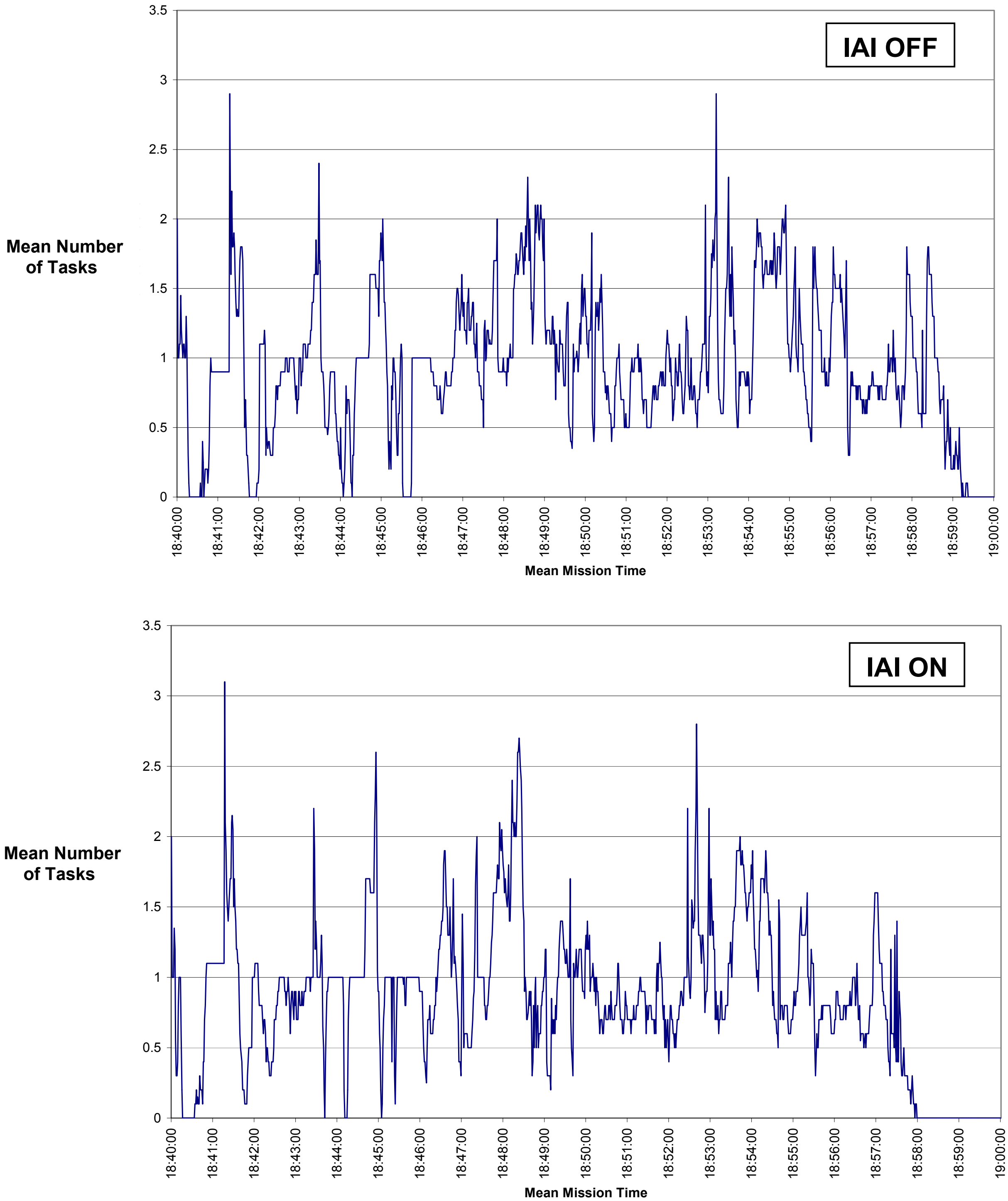
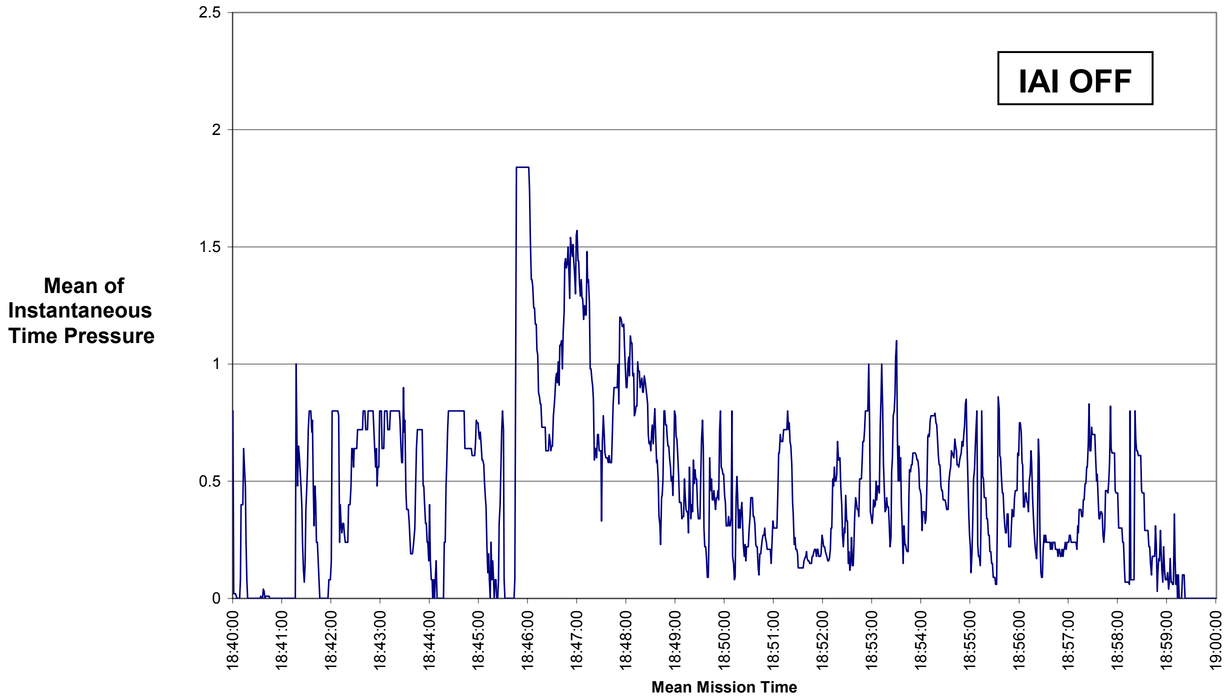


Figure 26 Scenario Part 3 – Number of Ongoing Tasks (UAV Pilot)



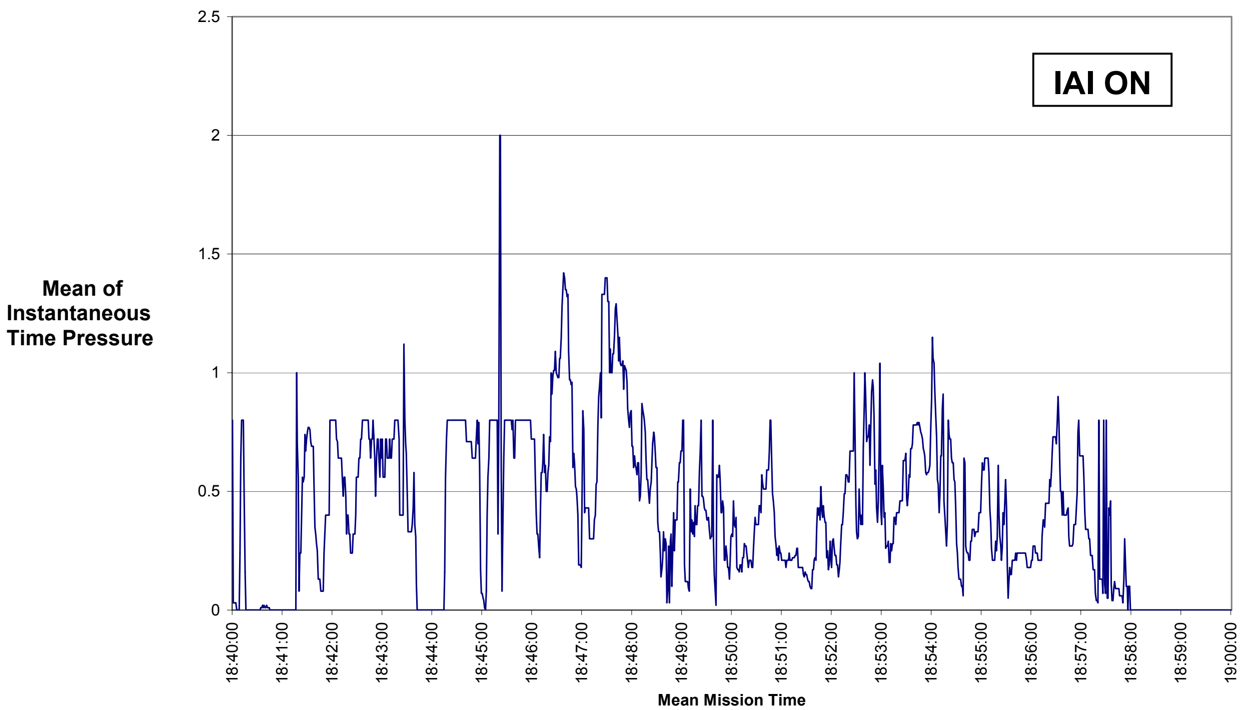


Figure 27 Scenario Part 3 – Mean of Instantaneous Time Pressure (UAV Pilot)

ANNEX F

IP/PCT TASK NETWORK DRAWINGS

14 June 2004

ANNEX F
IP/PCT TASK NETWORK DRAWINGS

Table 1 provides a list of the Network Drawings in this Annex as well as cross-references to the location of each flowchart.

Table 1 Network Flowcharts

Table 1 Network Flowcharts

Table 1 Network Flowcharts

Table 1 Network Flowcharts

Table 1 Network Flowcharts

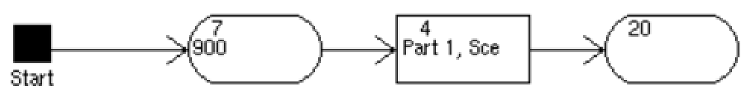


Figure F-1 Part 1 of Scenario – First Twenty Minutes

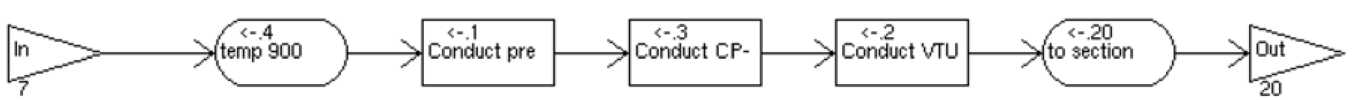


Figure F-2 Parts 1-1, 1-2 and 1-3 of Scenario – First Twenty Minutes

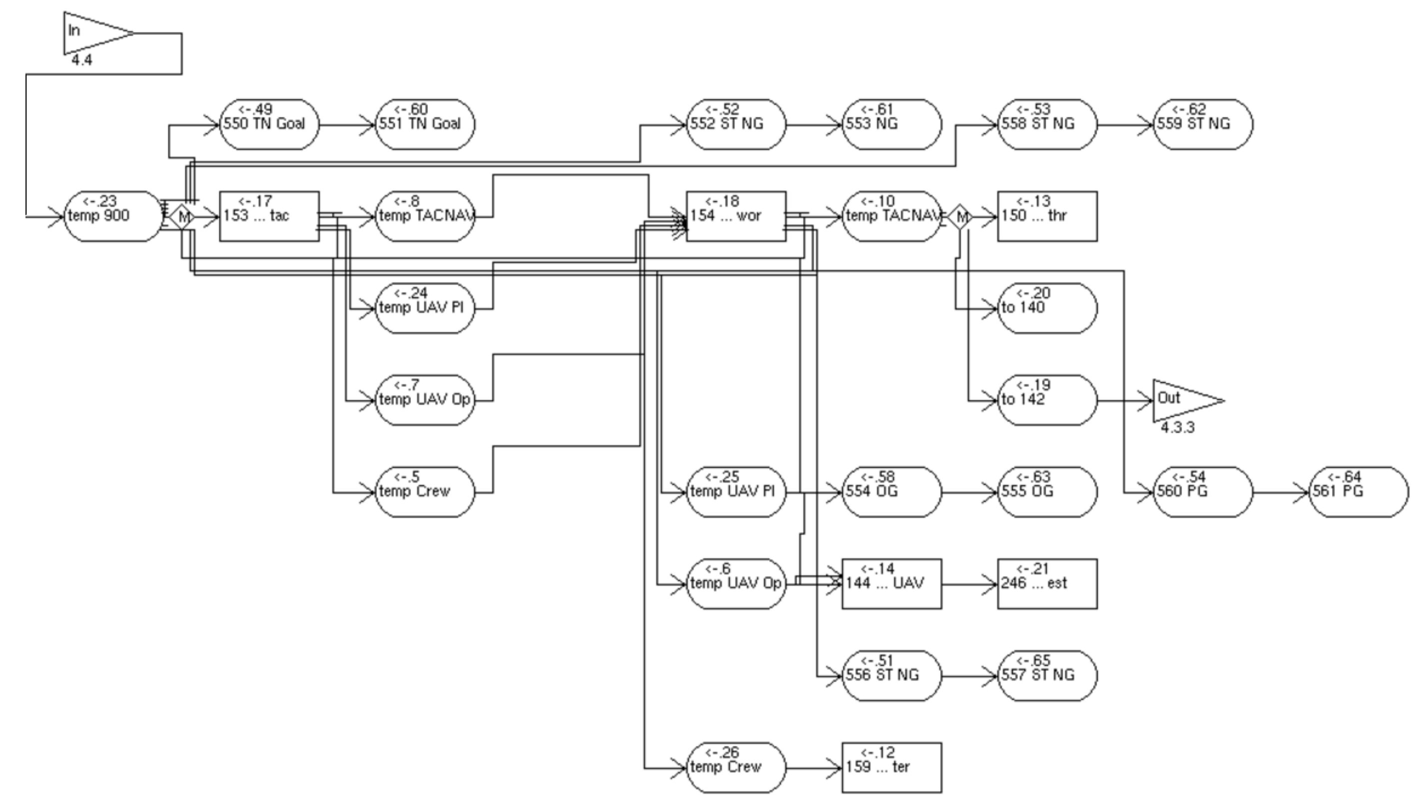


Figure F-3 Part 1-1 ... preparations for tasking are being conducted

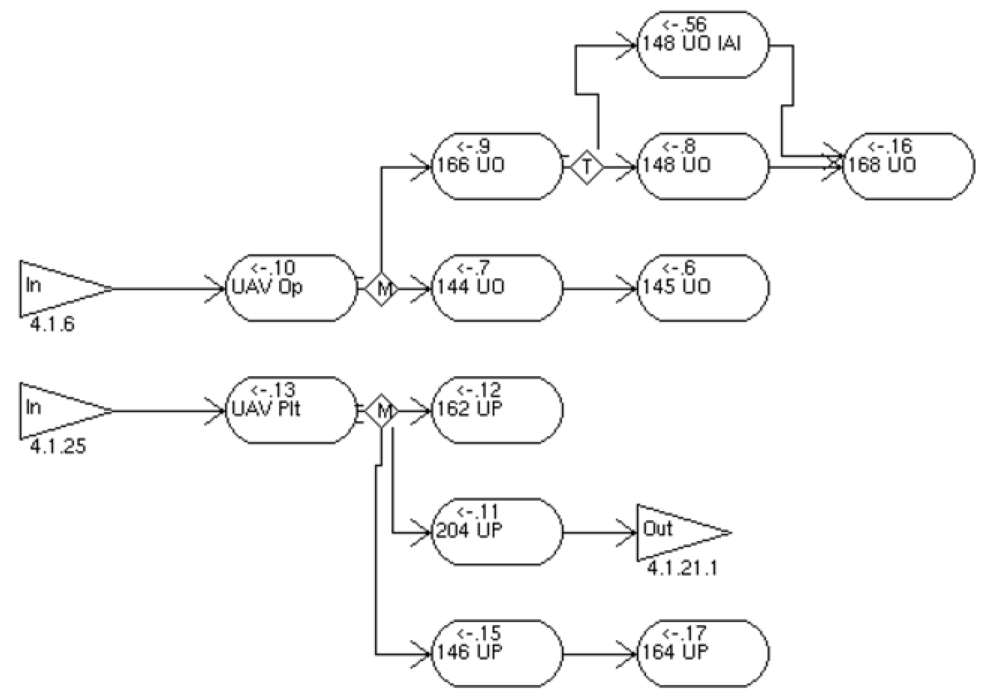


Figure F-4 Part 1-1 – Goal 144 ... UAV crew taking control of the VTUAV

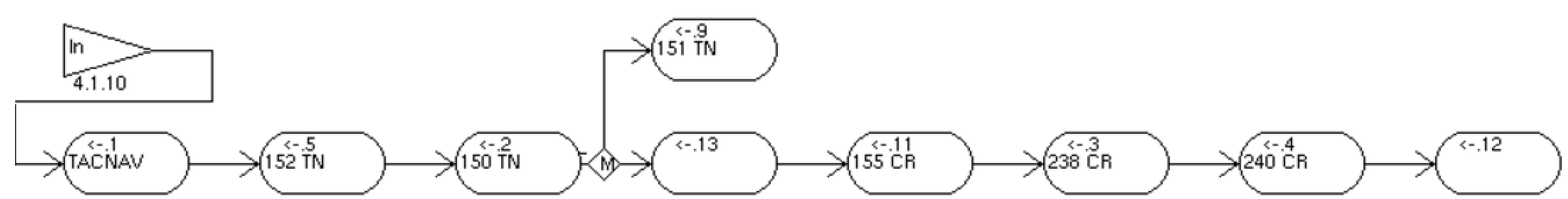


Figure F-5 Part 1-1 – Goal 150 ... threat is assessed

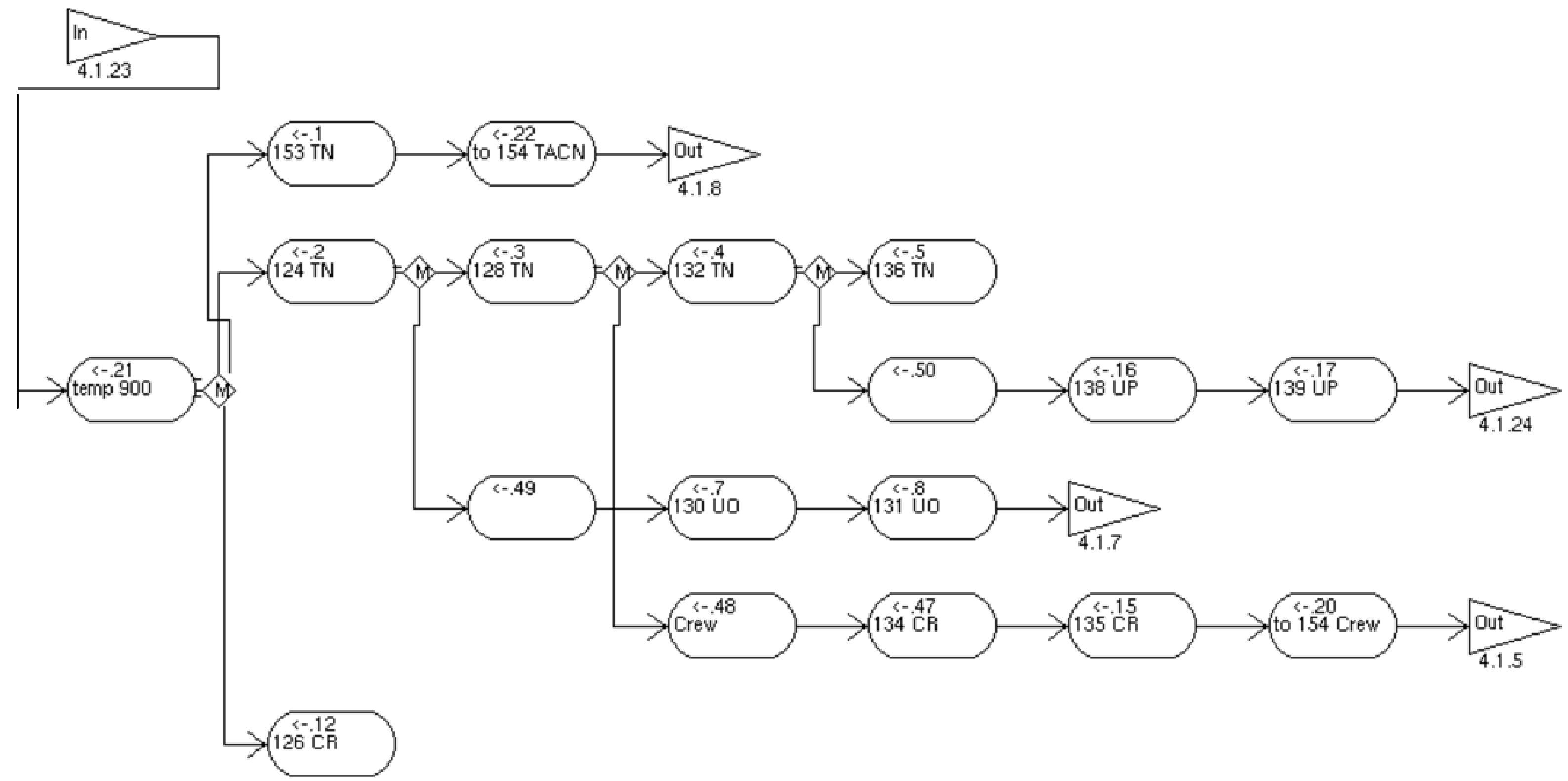


Figure F-6 Part 1-1– Goal 153 ... tactical crew reorganized

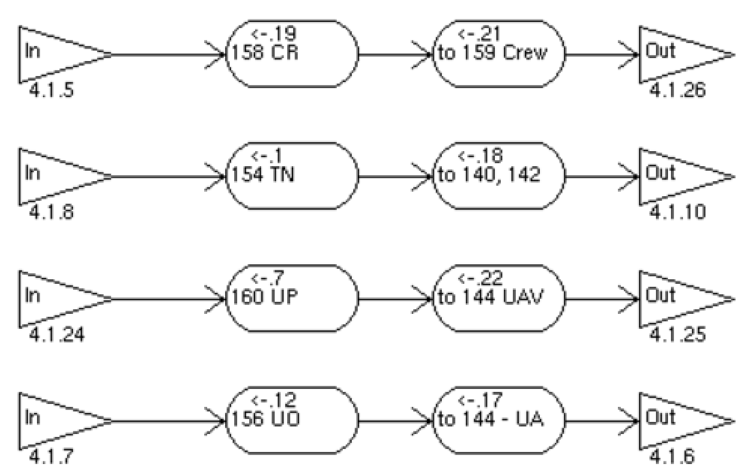


Figure F-7 Part 1-1– Goal 154 ... crew workstations configured

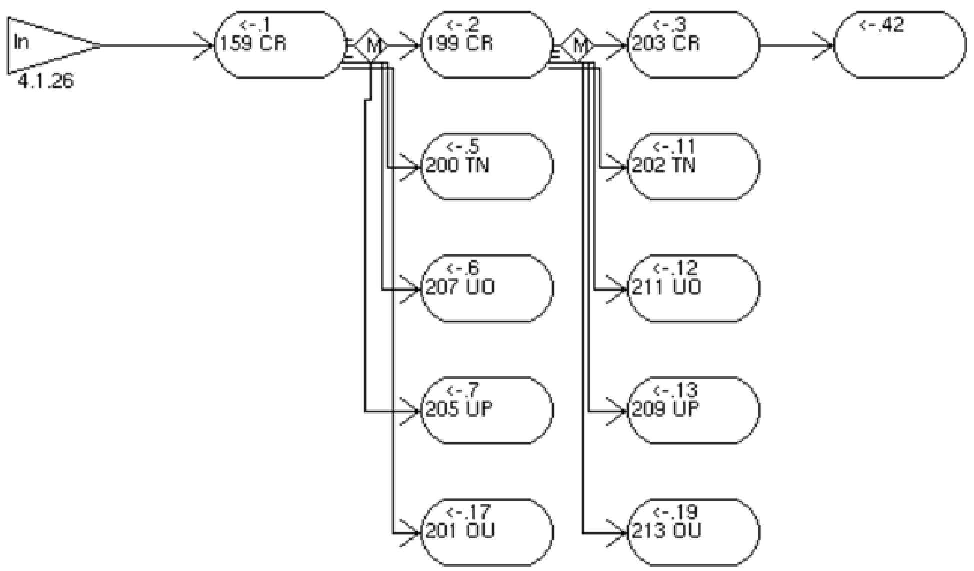


Figure F-8 Part 1-1– Goal 159 ... terrorist mission tasking acknowledged

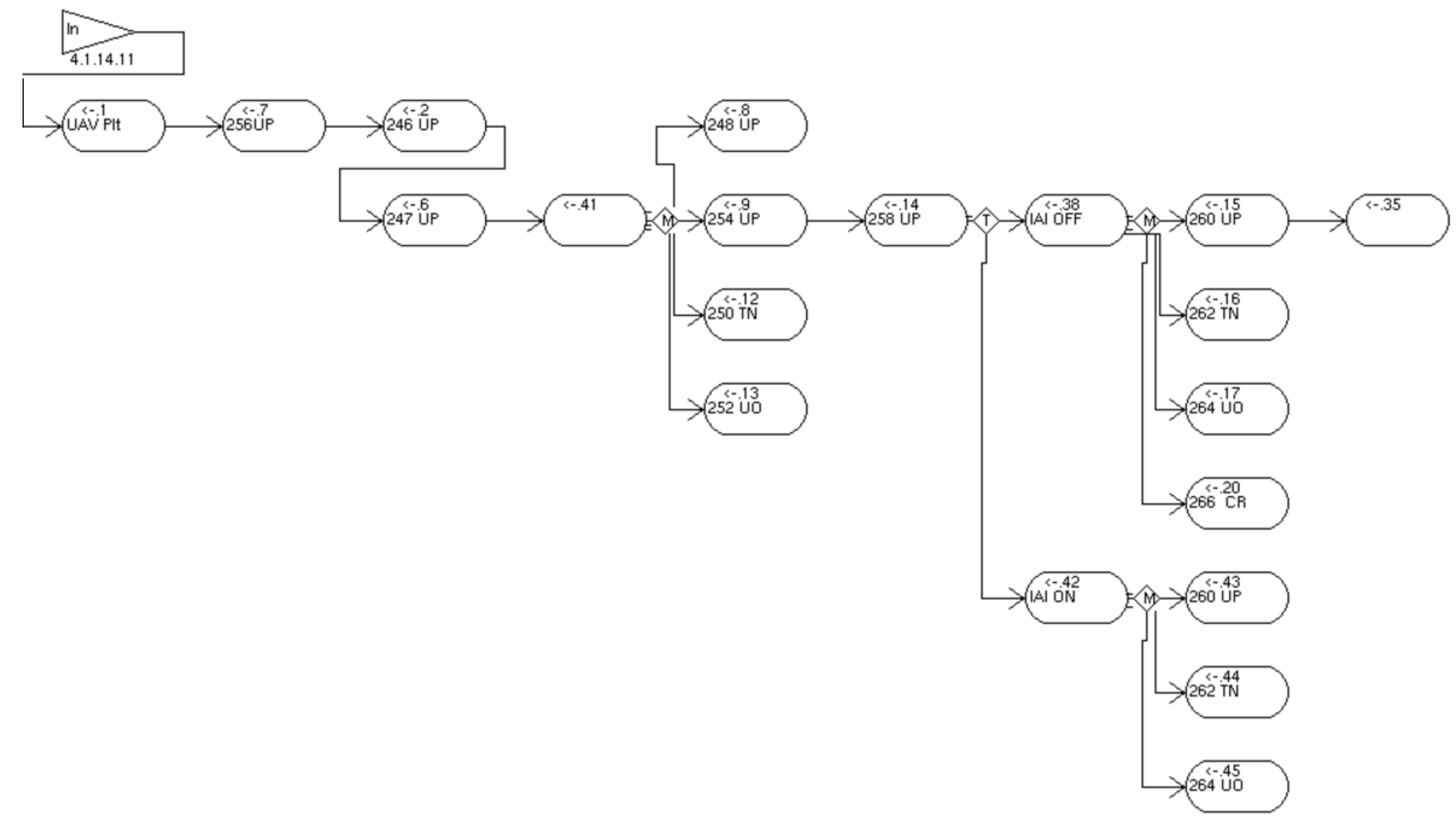


Figure F-9 Part 1-1– Goal 246 ... estimate of VTUAV time on task

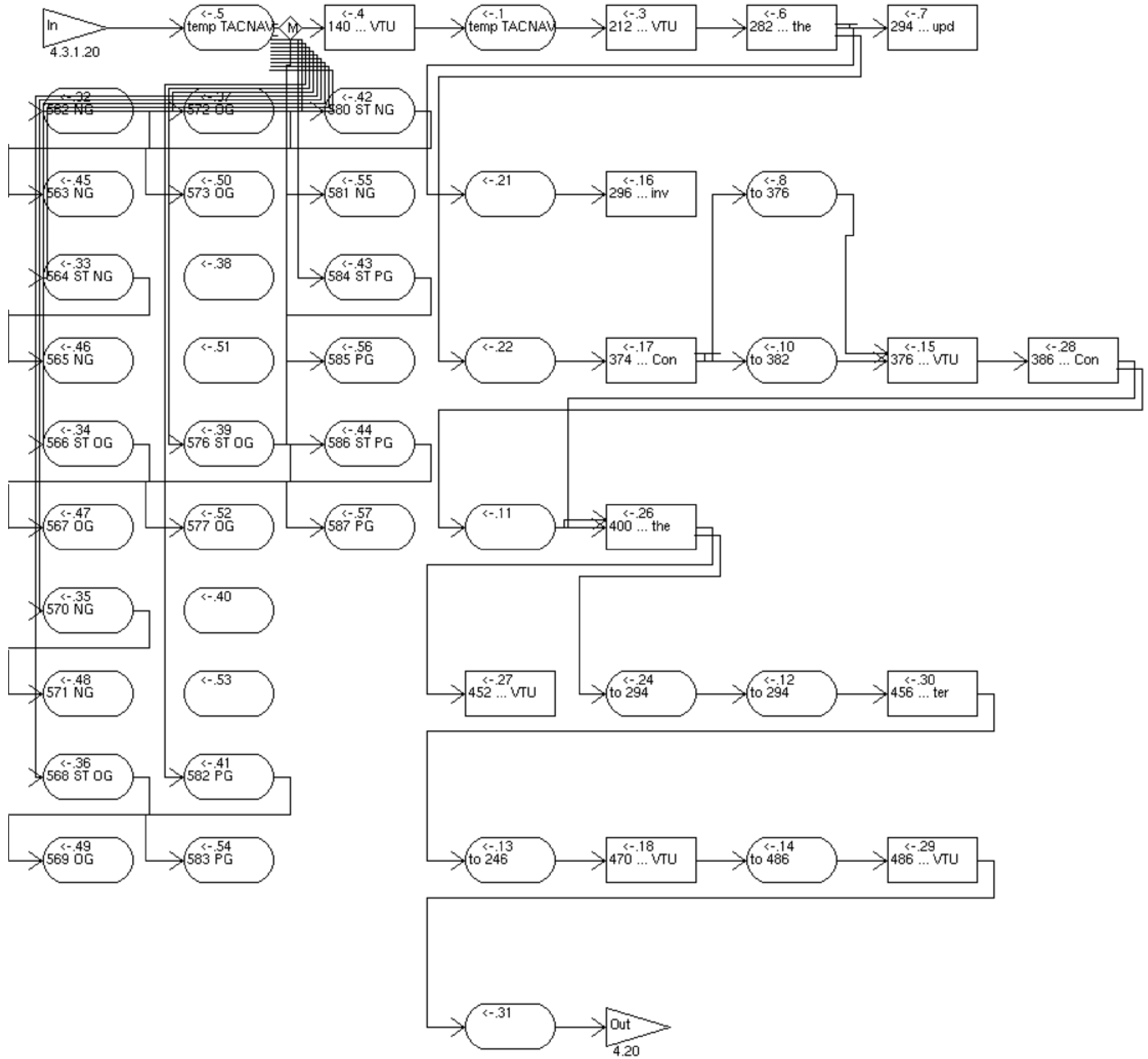


Figure F-10 Part 1-2 … VTUAV operations are conducted (search for terrorist boat)

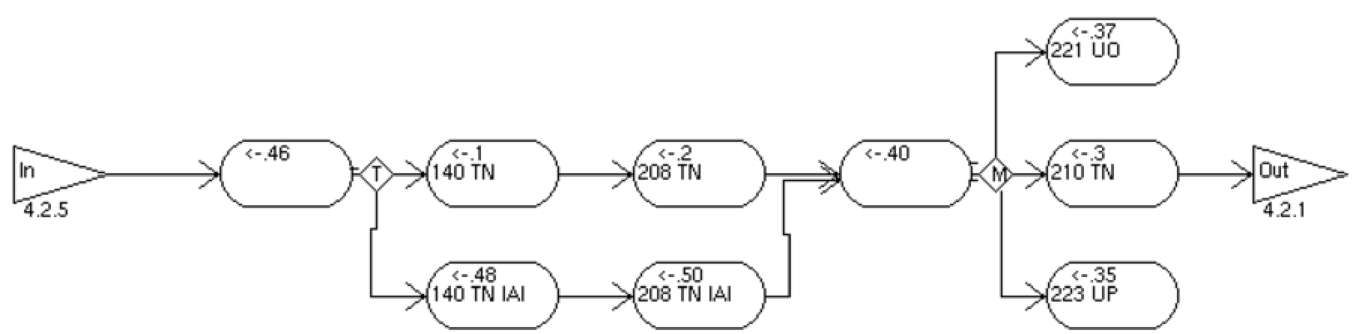


Figure F-11   Part 1-2 – Goal 140 ... VTUAV route planned to next contact

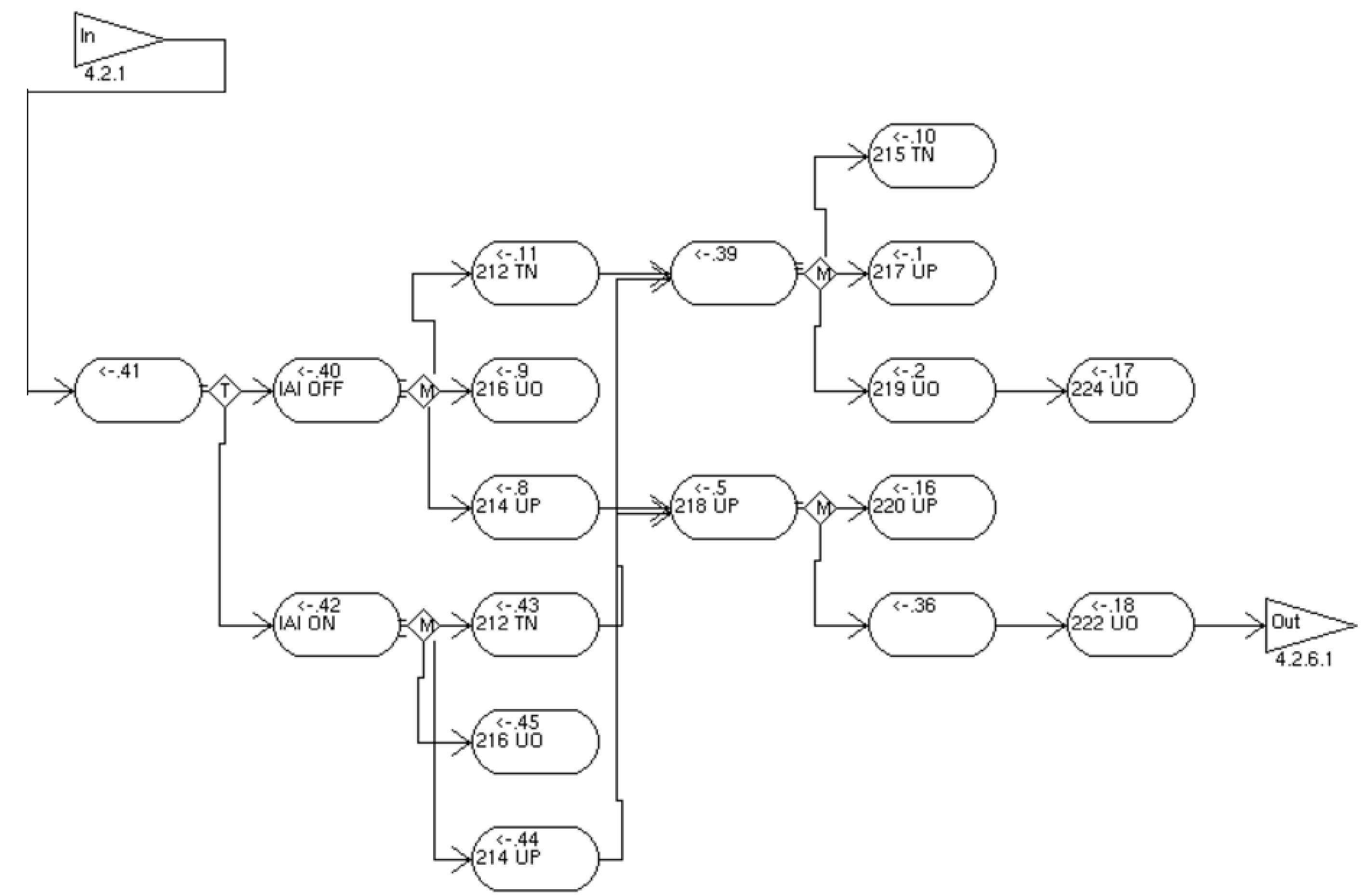


Figure F-12   Part 1-2 – Goal 212 ... VTUAV route initiated by UAV crew

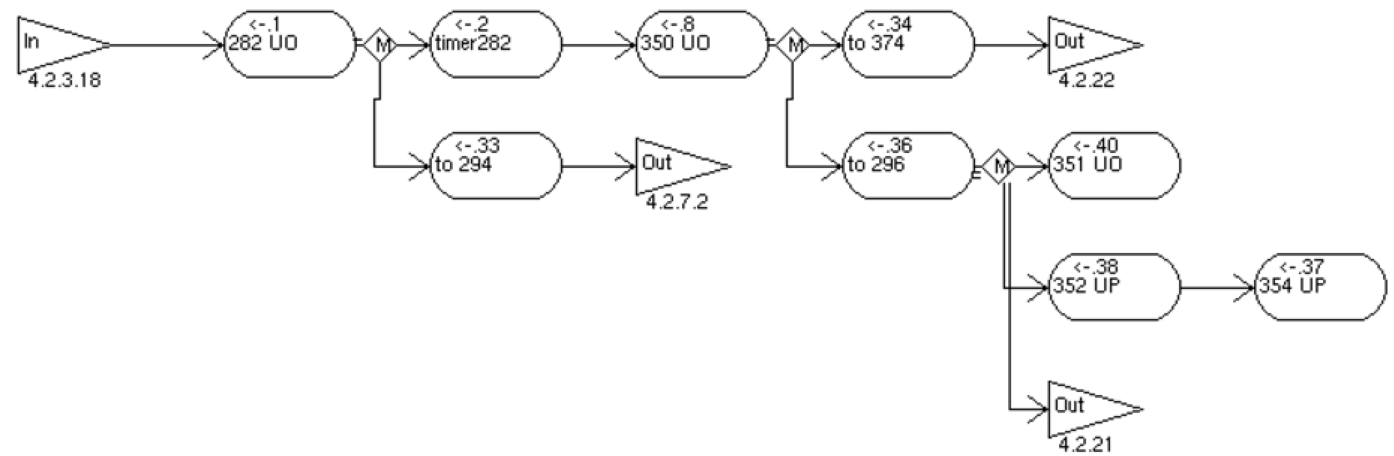


Figure F-13 Part 1-2 – Goal 282 ... the expected location of contact is searched

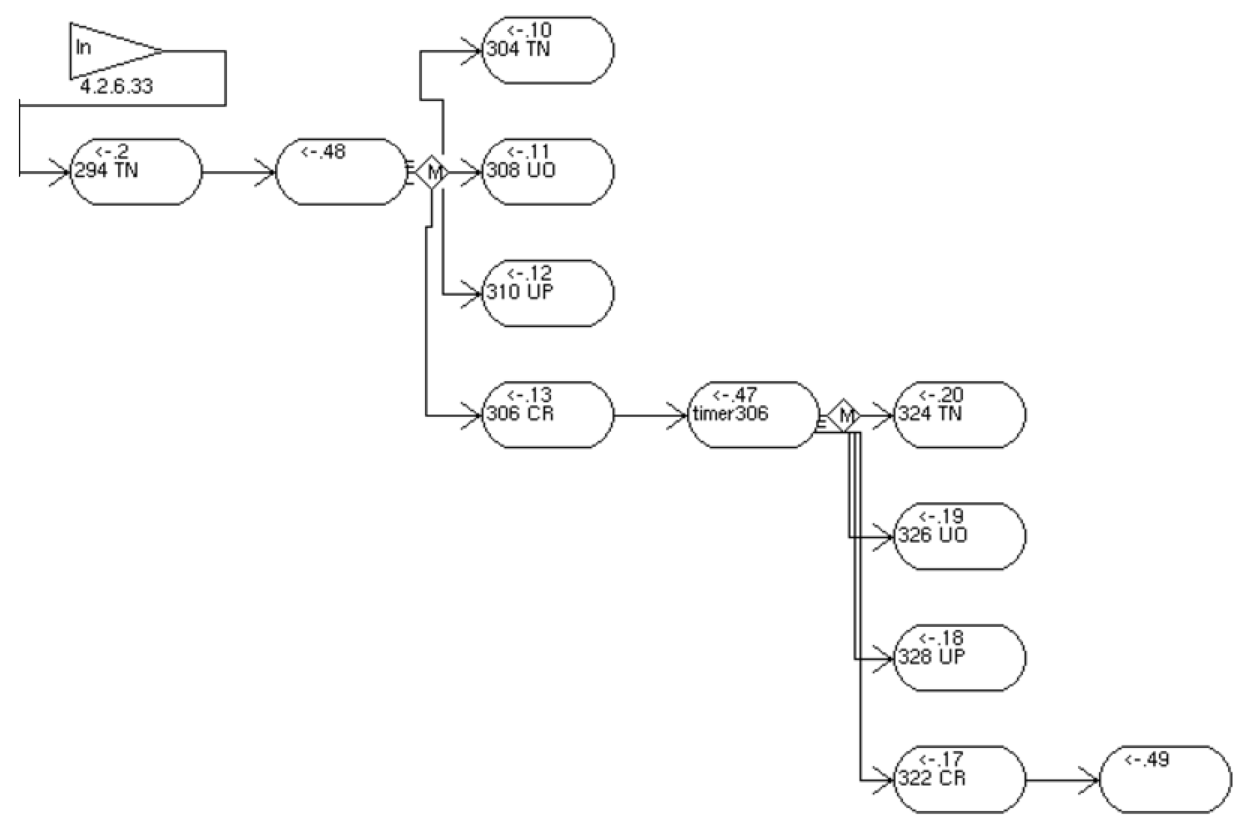


Figure F-14 Part 1-2 – Goal 294 ... updated surface plot requested

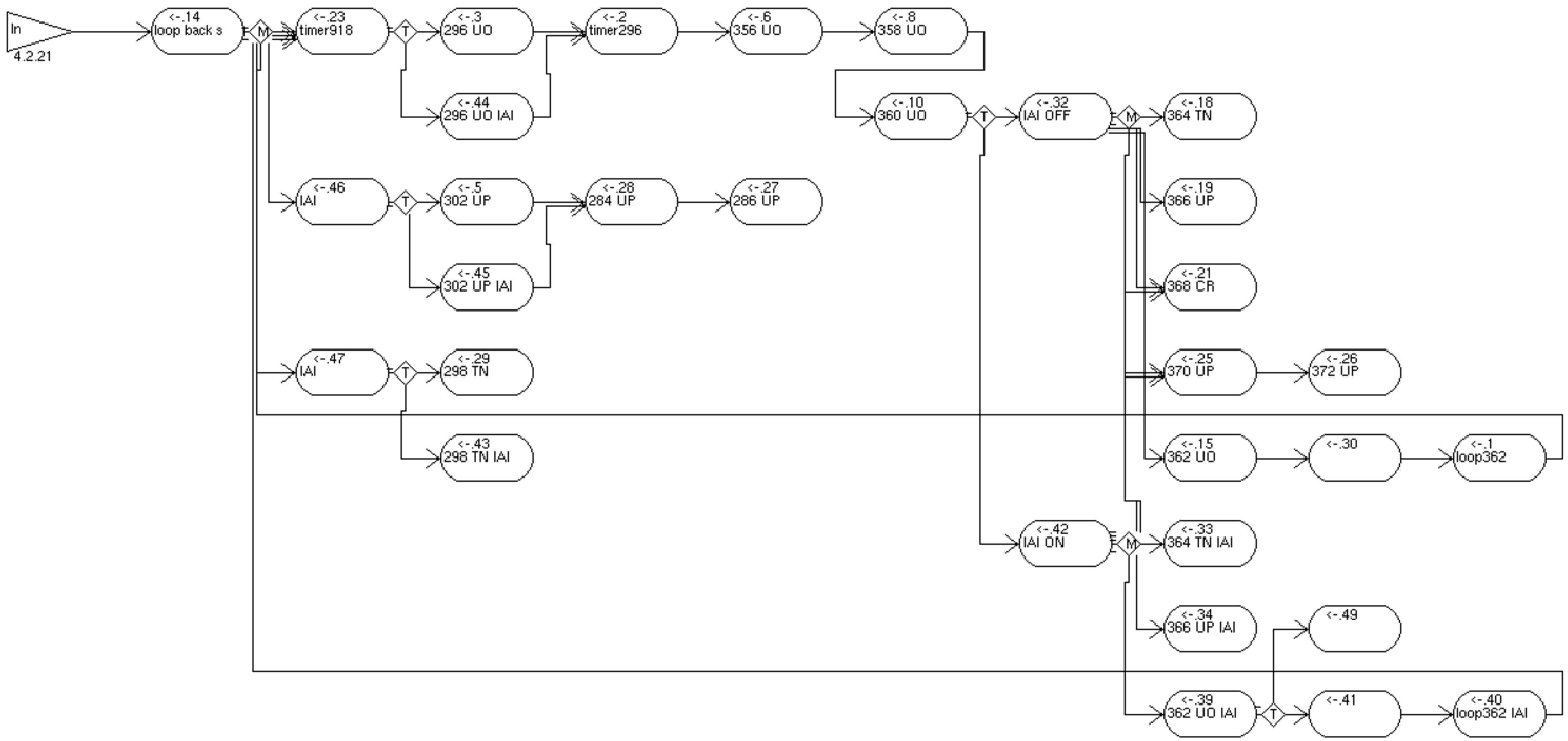


Figure F-15 Part 1-2 – Goal 296 ... investigation of Contact 2

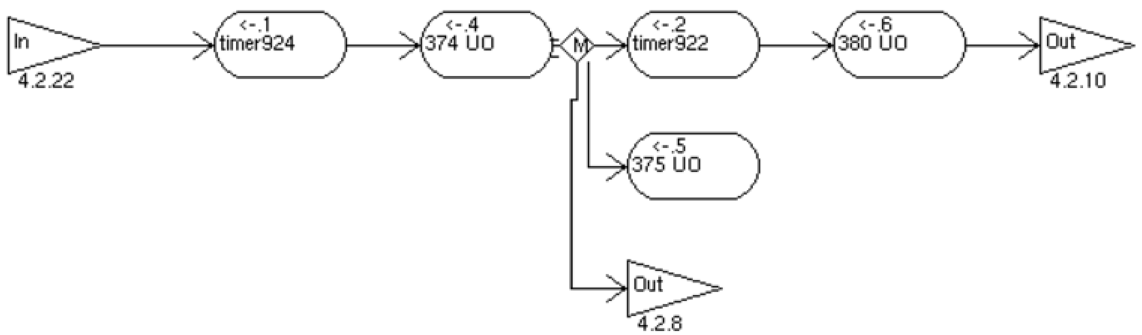


Figure F-16 Part 1-2 – Goal 374 ... Contact 2 located on VTUAV radar

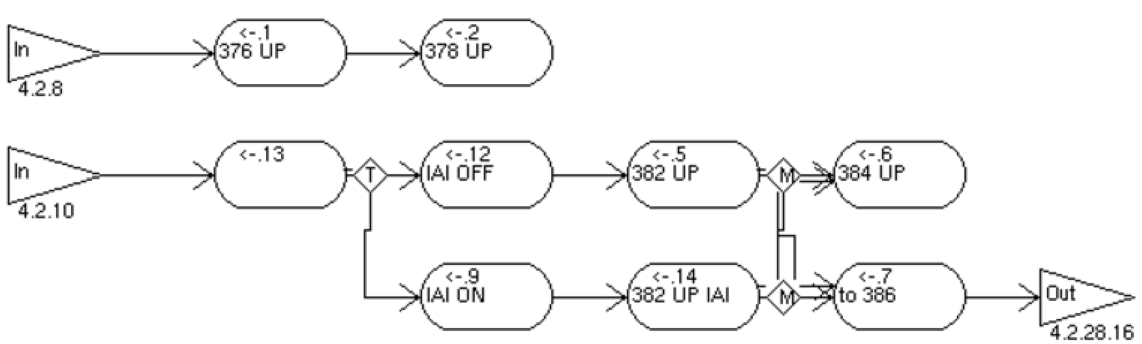


Figure F-17 Part 1-2 – Goal 376 ... VTUAV route (Contact 2) is initiated and flown

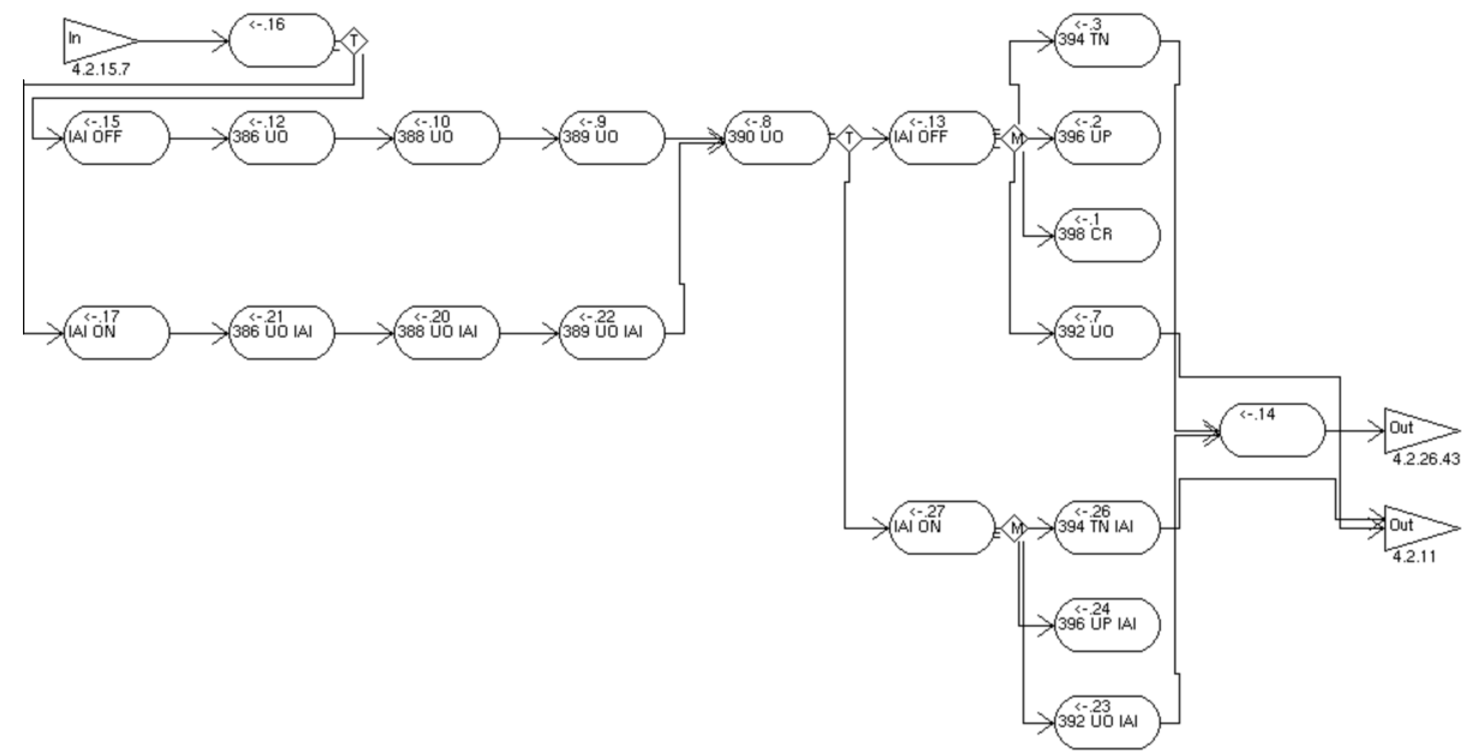


Figure F-18 Part 1-2 – Goal 386 ... Contact 2 is identified using VTUAV EO

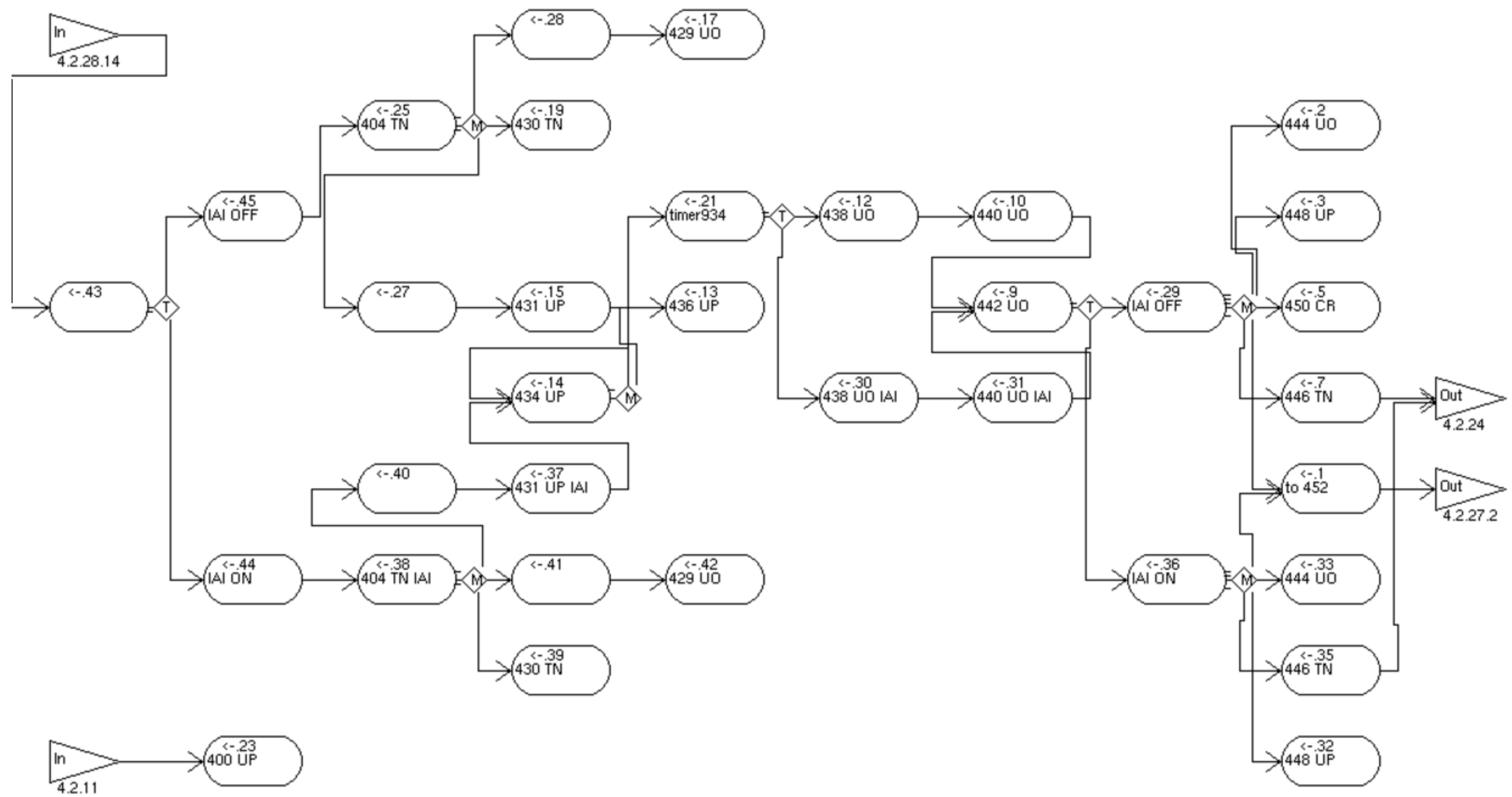


Figure F-19 Part 1-2 – Goal 400 ... the target of opportunity is investigated

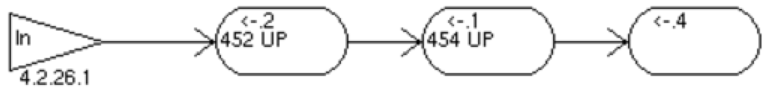


Figure F-20 Part 1-2 – Goal 452 ... VTUAV tracking towards the waypoint

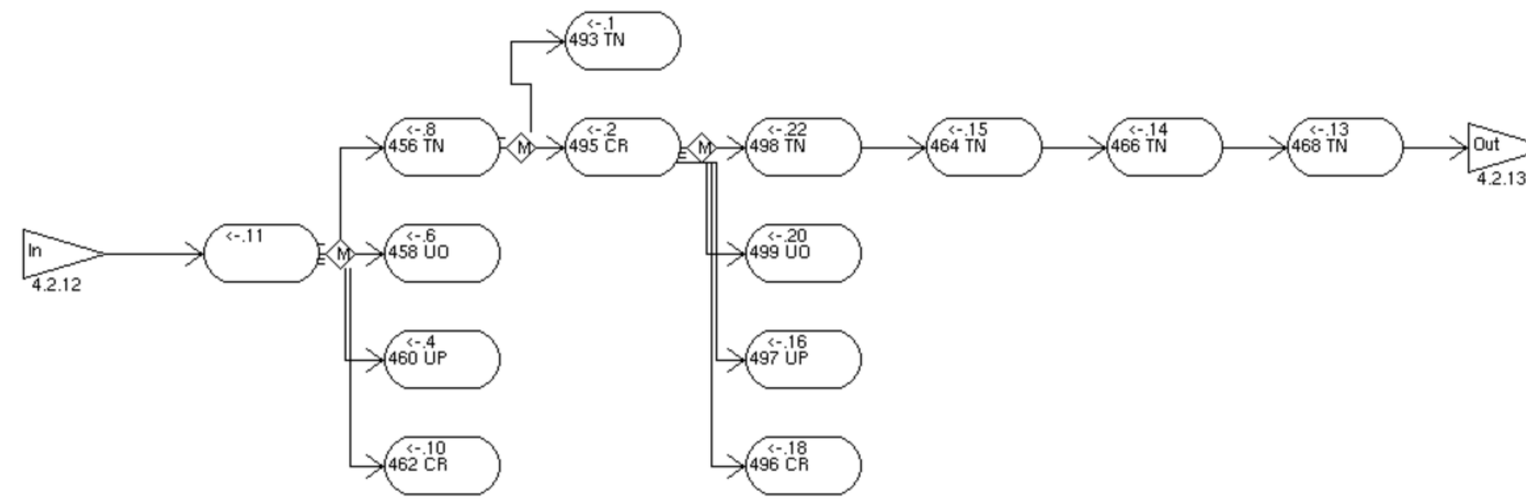


Figure F-22 Part 1-2 – Goal 456 ... terrorist mission planning with ROC

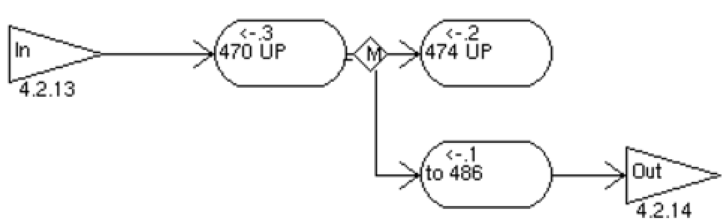


Figure F-21 Part 1-2 – Goal 470 ... VTUAV route (Contact 5) is initiated and flown

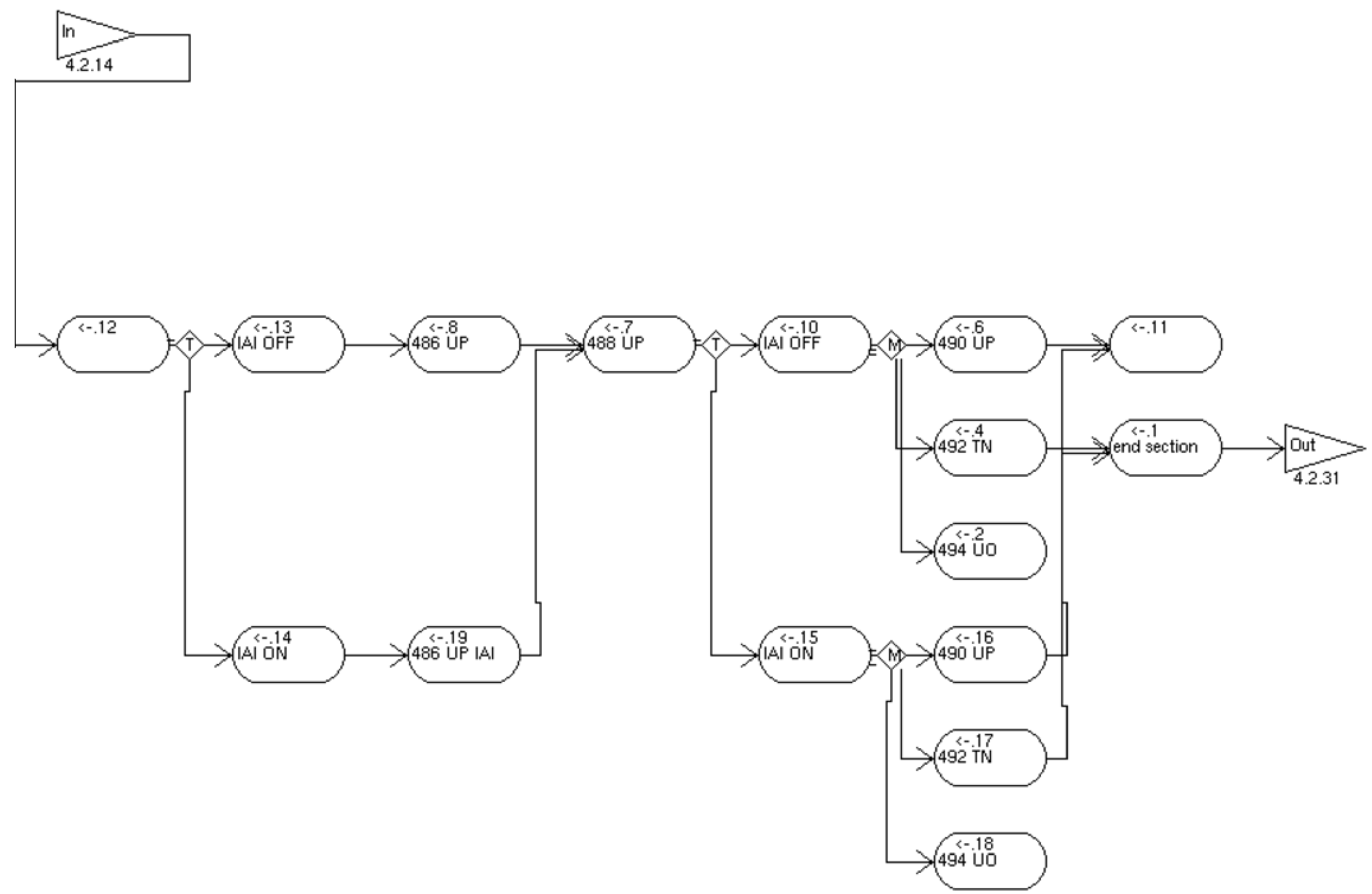


Figure F-23 Part 1-2 – Goal 486 ... VTUAV refuelling is planned

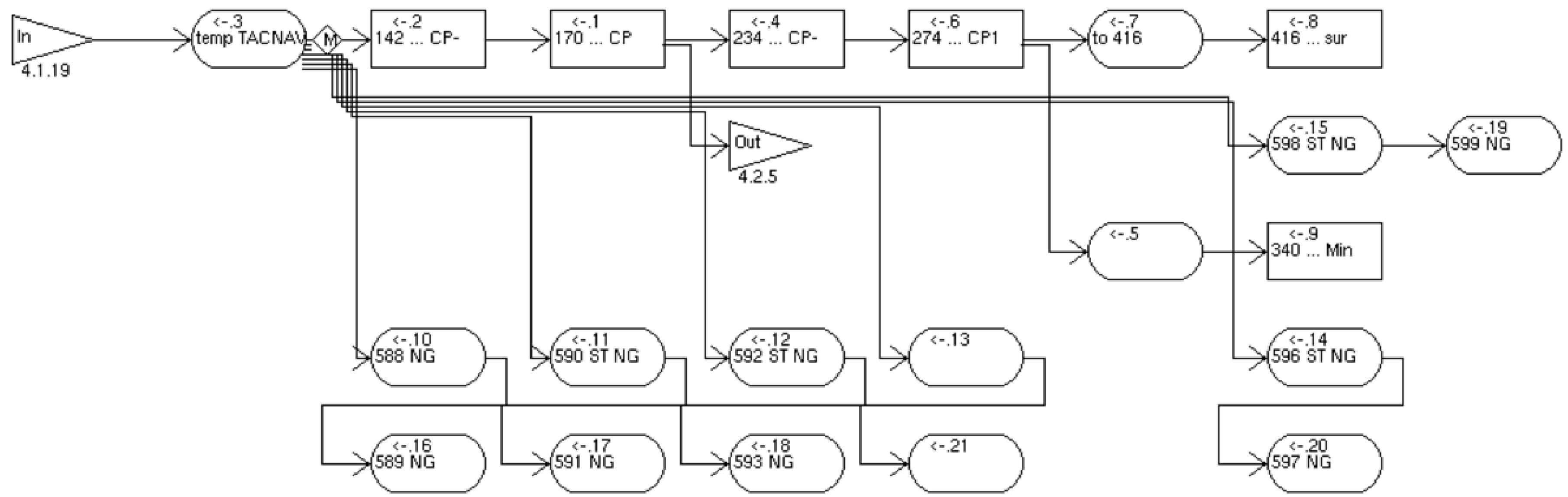


Figure F-24 Part 1-3 … CP140 operations are conducted (search for terrorist boat)

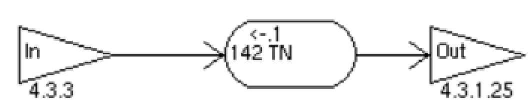


Figure F-25 Part 1-3 – Goal 142 ... CP140 route planned to next contact

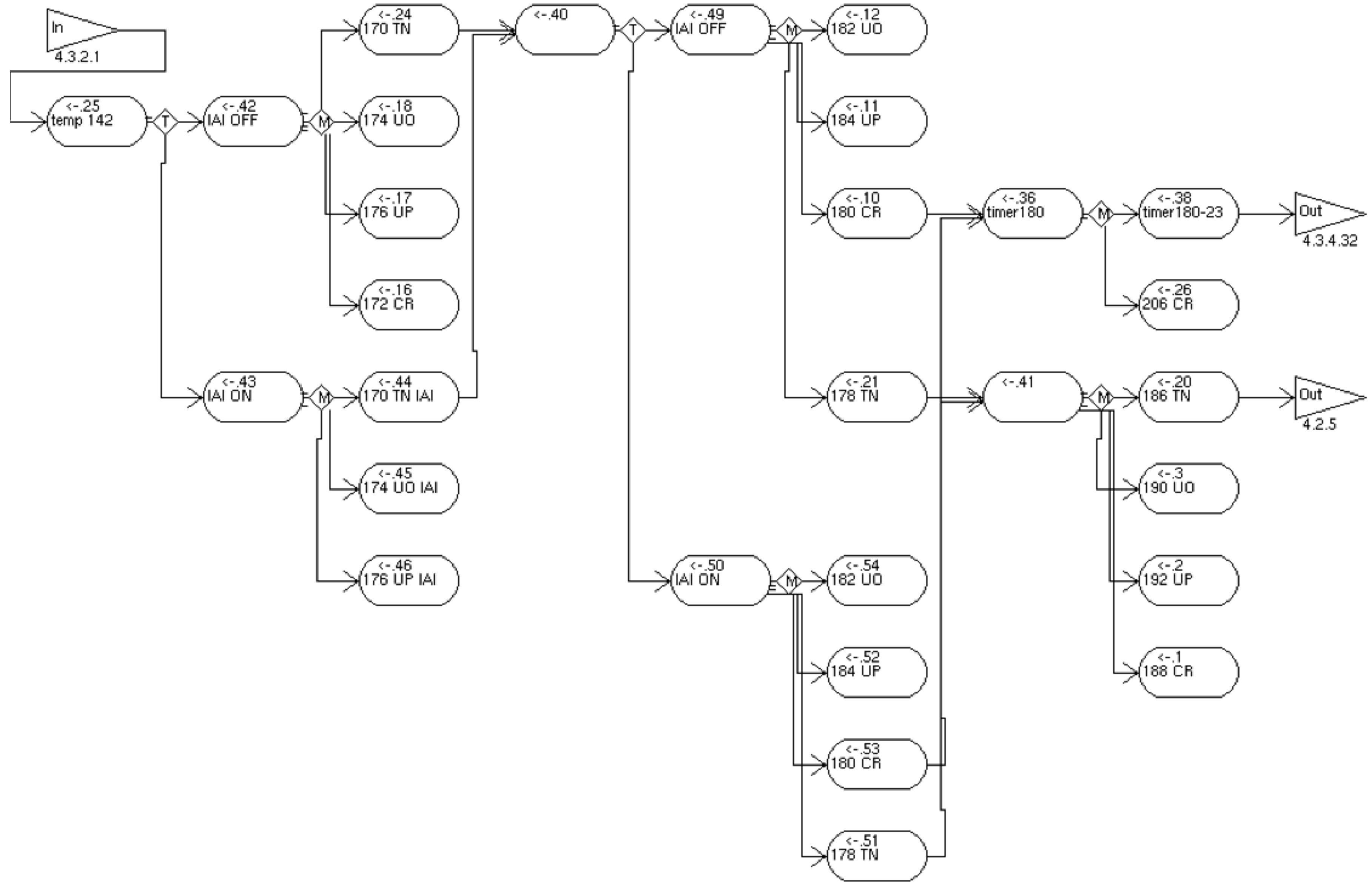


Figure F-26 Part 1-3 – Goal 170 ... CP140 en route to contact

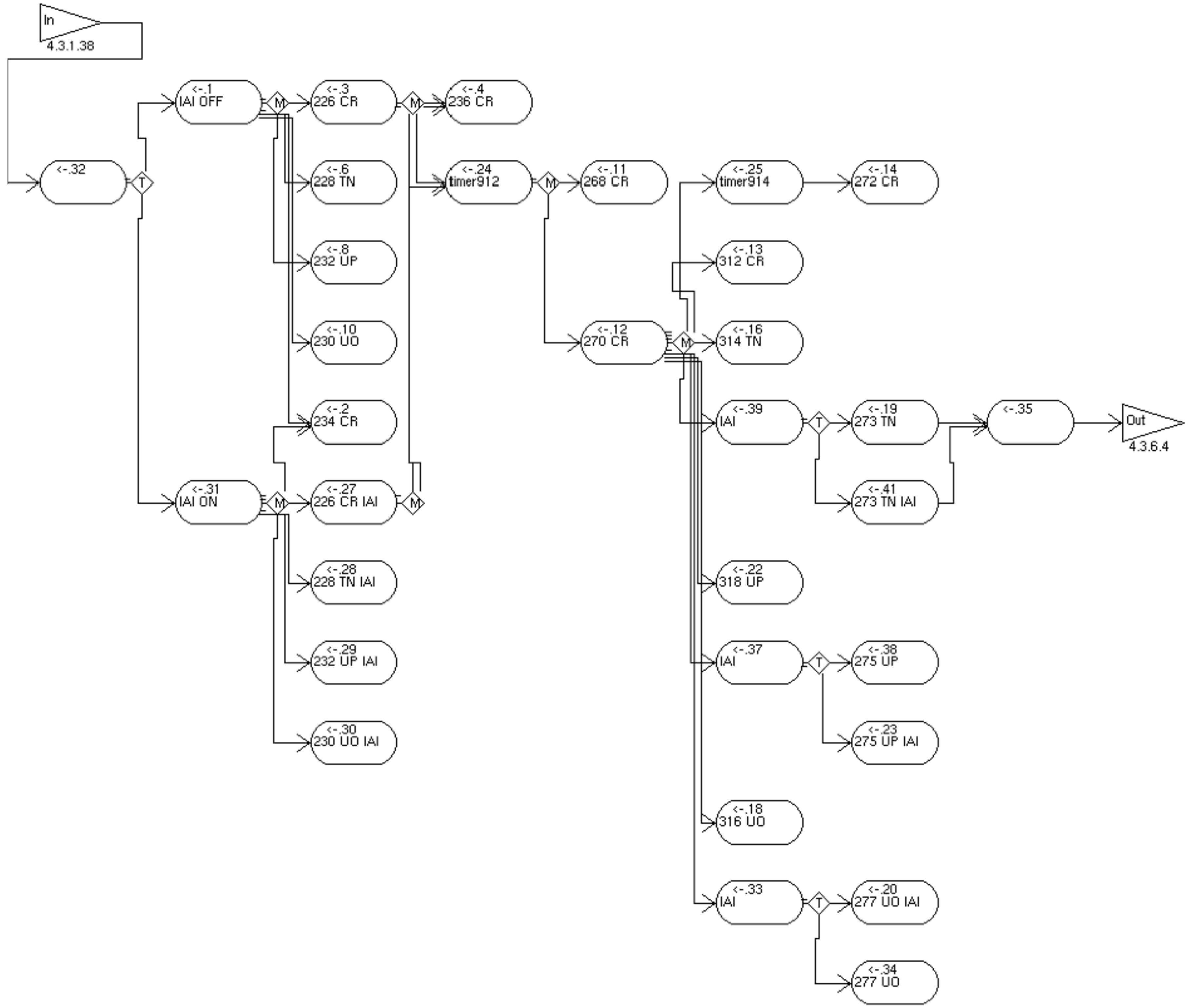


Figure F-27 Part 1-3 – Goal 234 ... CP140 approaching and identifying Contact 4

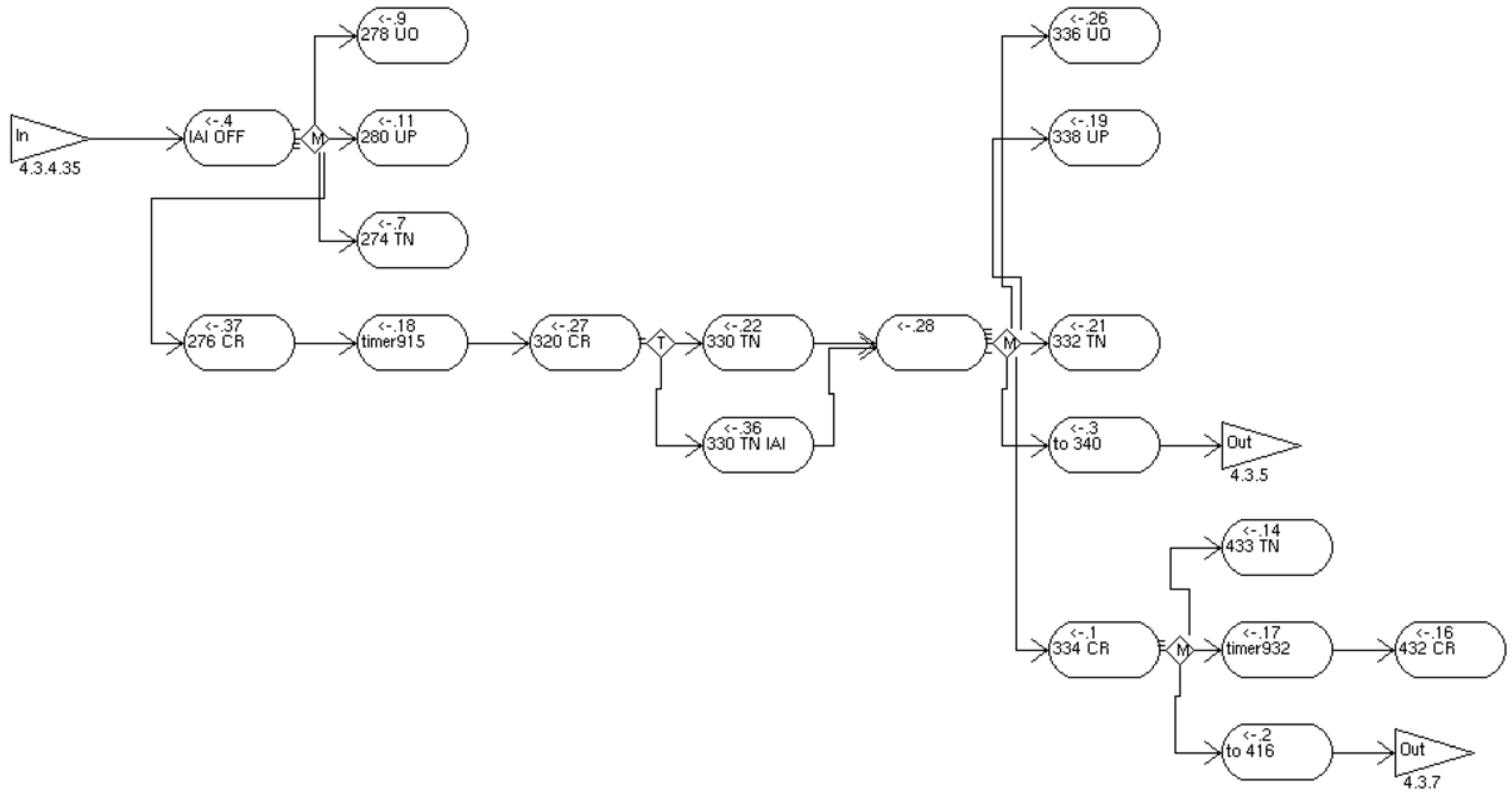


Figure F-28 Part 1-3 – Goal 274 ... CP140 is en route to Contact 4

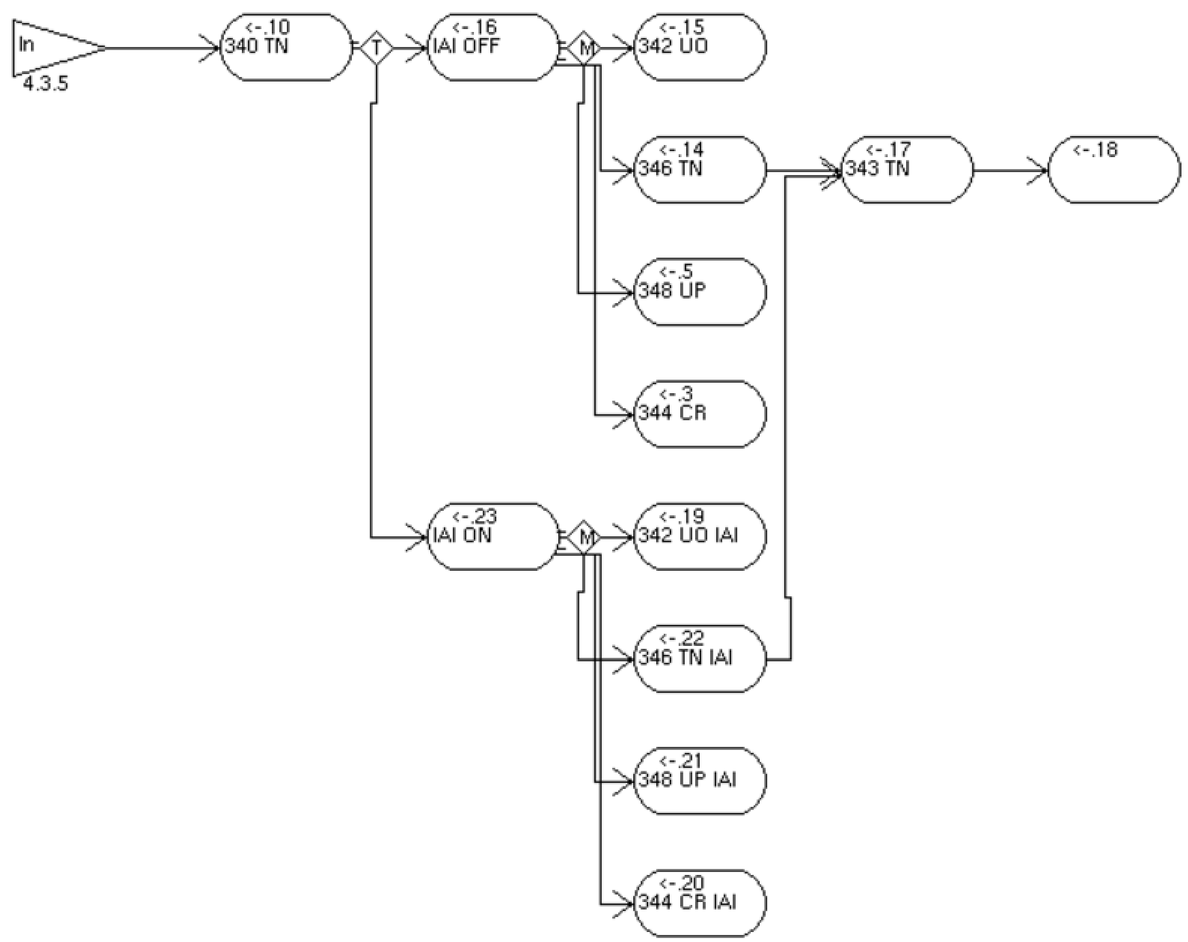


Figure F-29 Part 1-3 – Goal 340 ... Mini UAV prepared for release over Contact 4

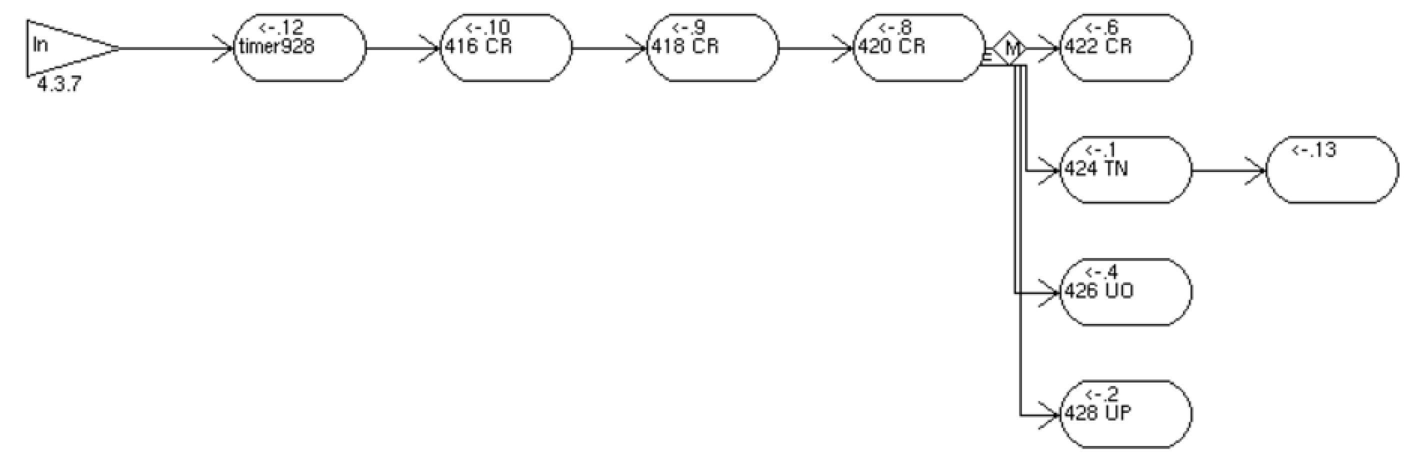


Figure F-30 Part 1-3 – Goal 416 ... surface plot updated using the CP140 radar

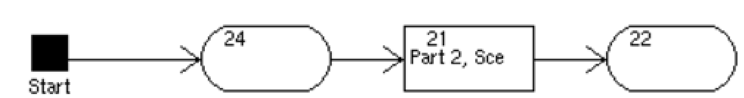


Figure F-31 Part 2 of Scenario – Second Twenty Minutes

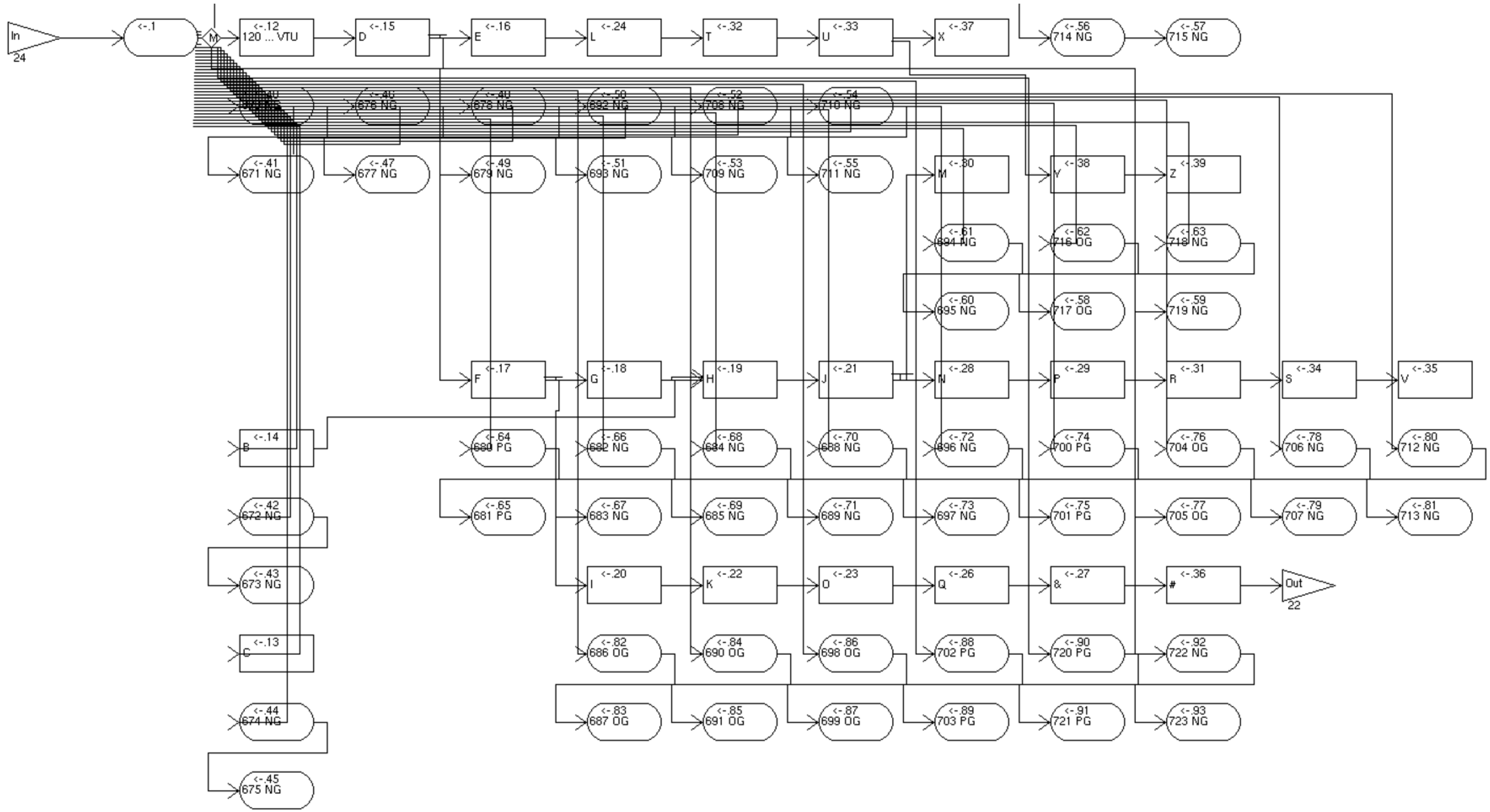


Figure F-32 Part 2 of Scenario – Second Twenty Minutes

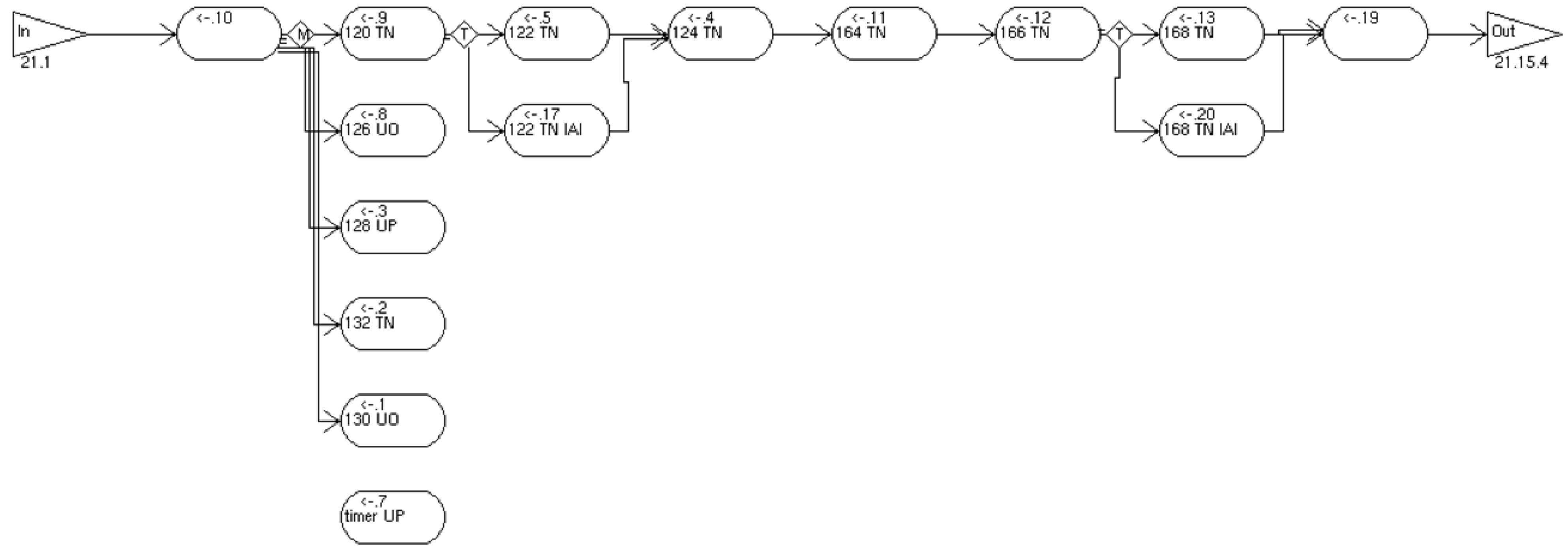


Figure F-33 Part 2 – Goal 120 ... VTUAV 1 employment has been planned

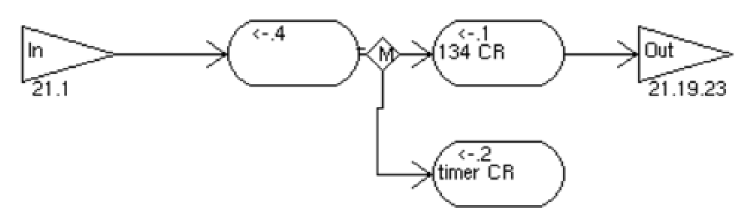


Figure F-34 Part 2 – Goal 134 ... CP140 is level at 4000 ft en route to Contact 4

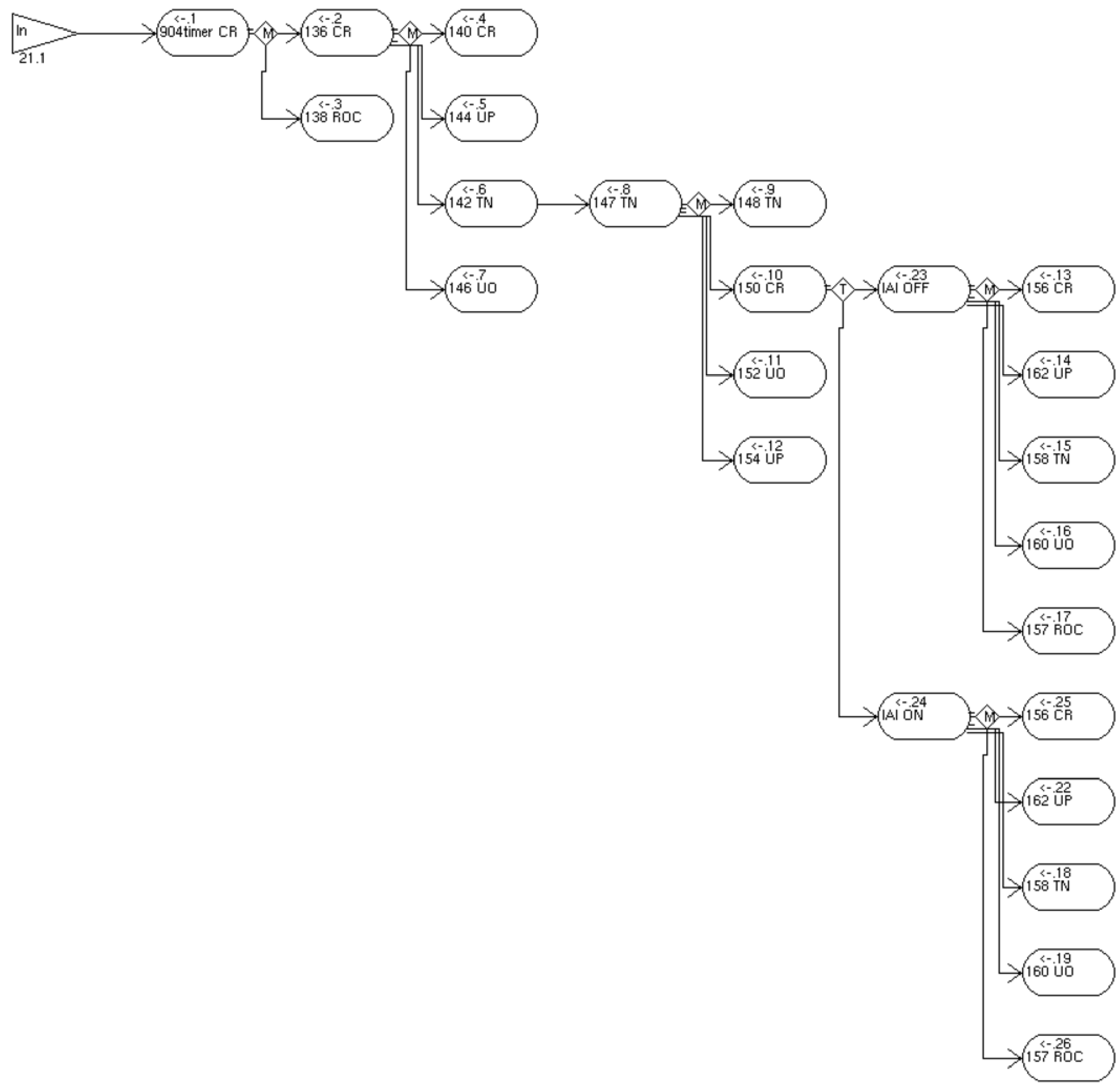


Figure F-35 Part 2 – Goal 136 ... MALE UAV has been tasked to investigate Contact 3

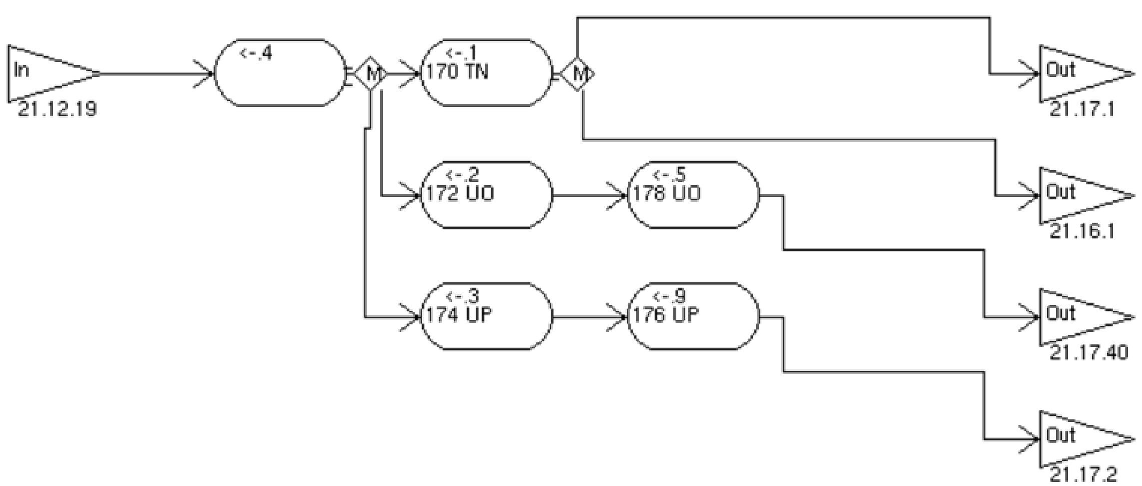


Figure F-36 Part 2 – Goal 170 … UAV Operator and Pilot intend to investigate Boat 1

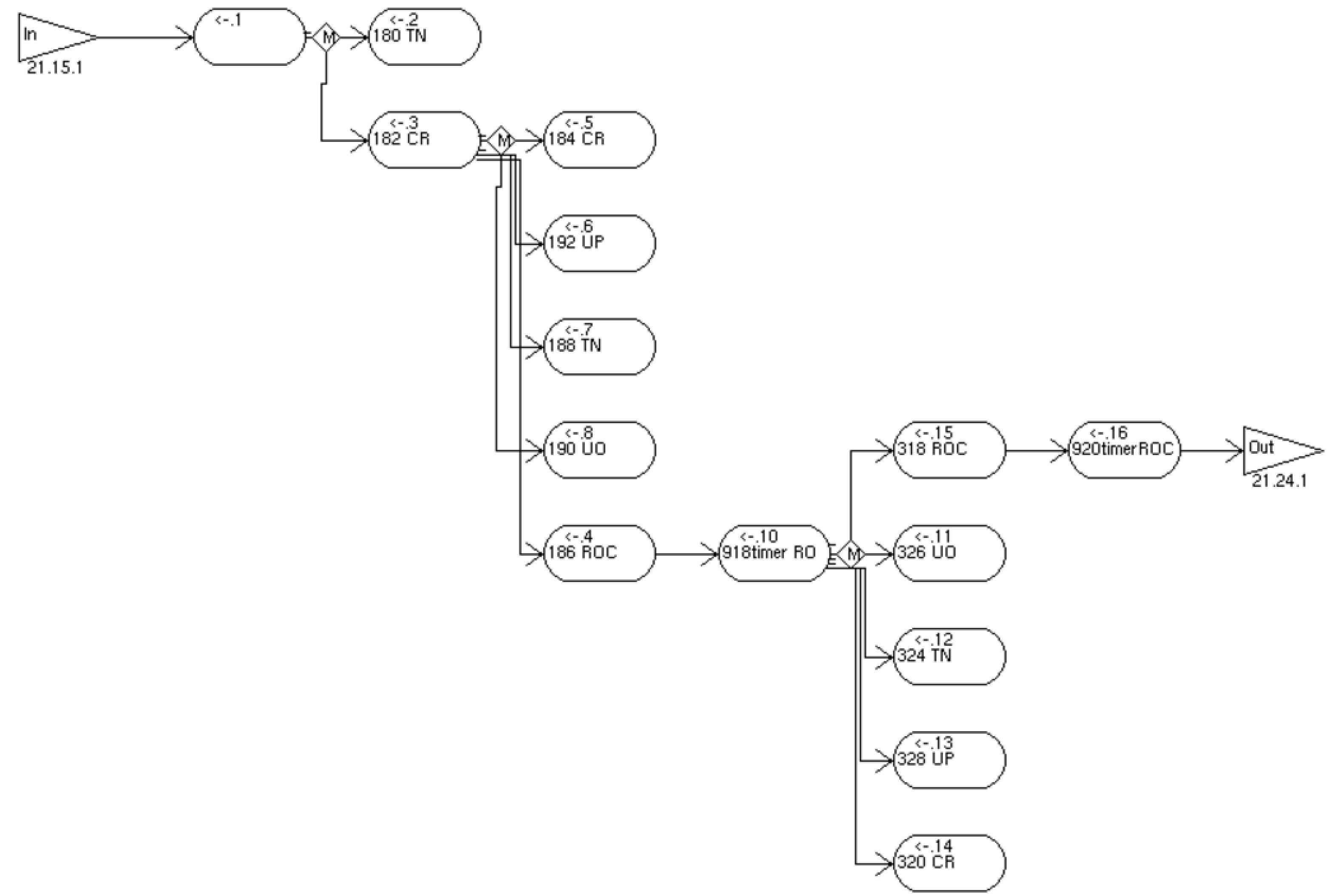


Figure F-37 Part 2 – Goal 180 ... the MALE UAV will conduct ISAR imaging of Boat 3

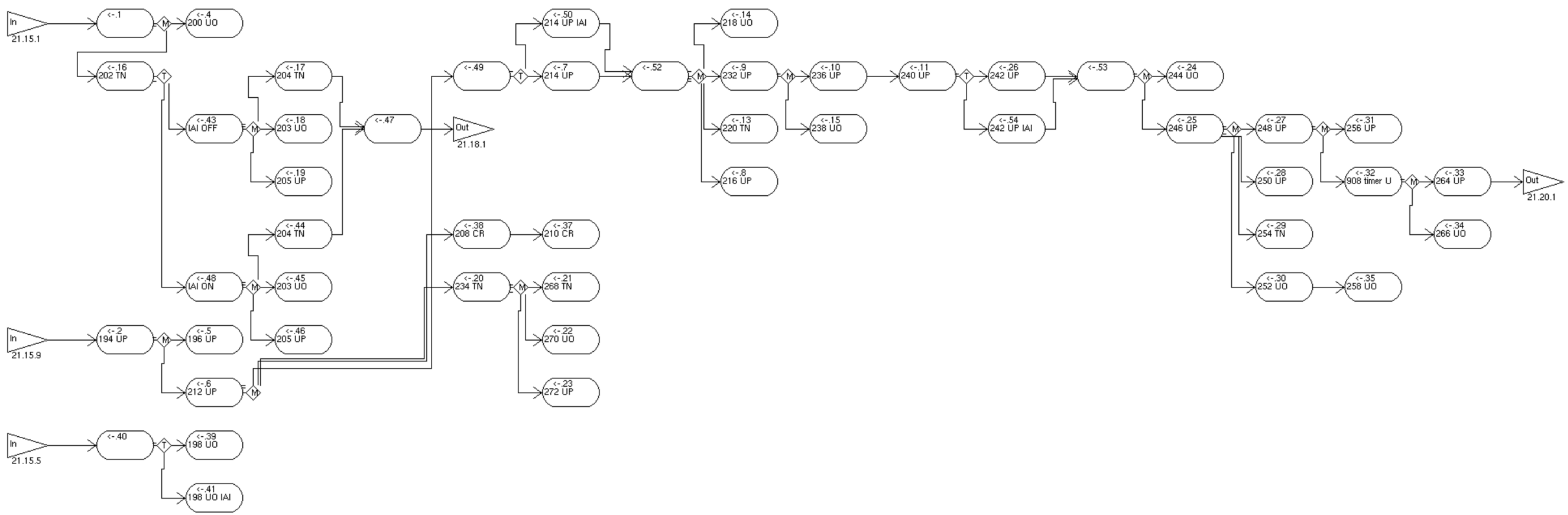


Figure F-38 Part 2 – Goal 194 ... VTUAV 1 is cautiously approaching Boat 1

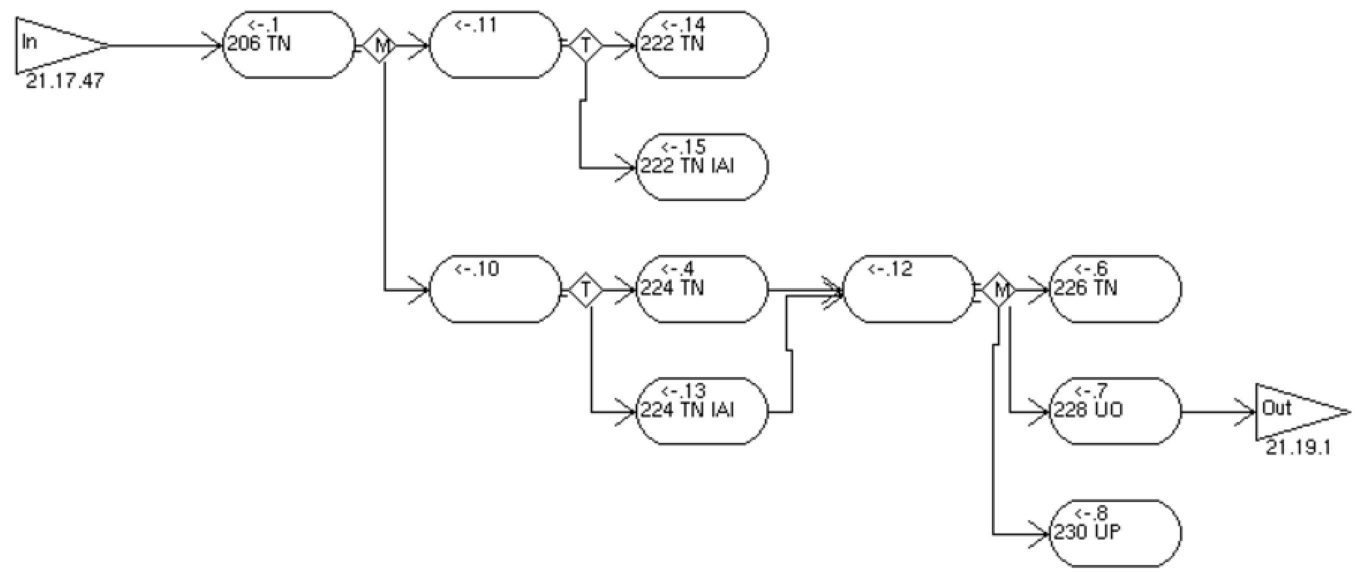


Figure F-39   Part 2 – Goal 206 ... plan for investigation of Contact 4 using a Mini UAV

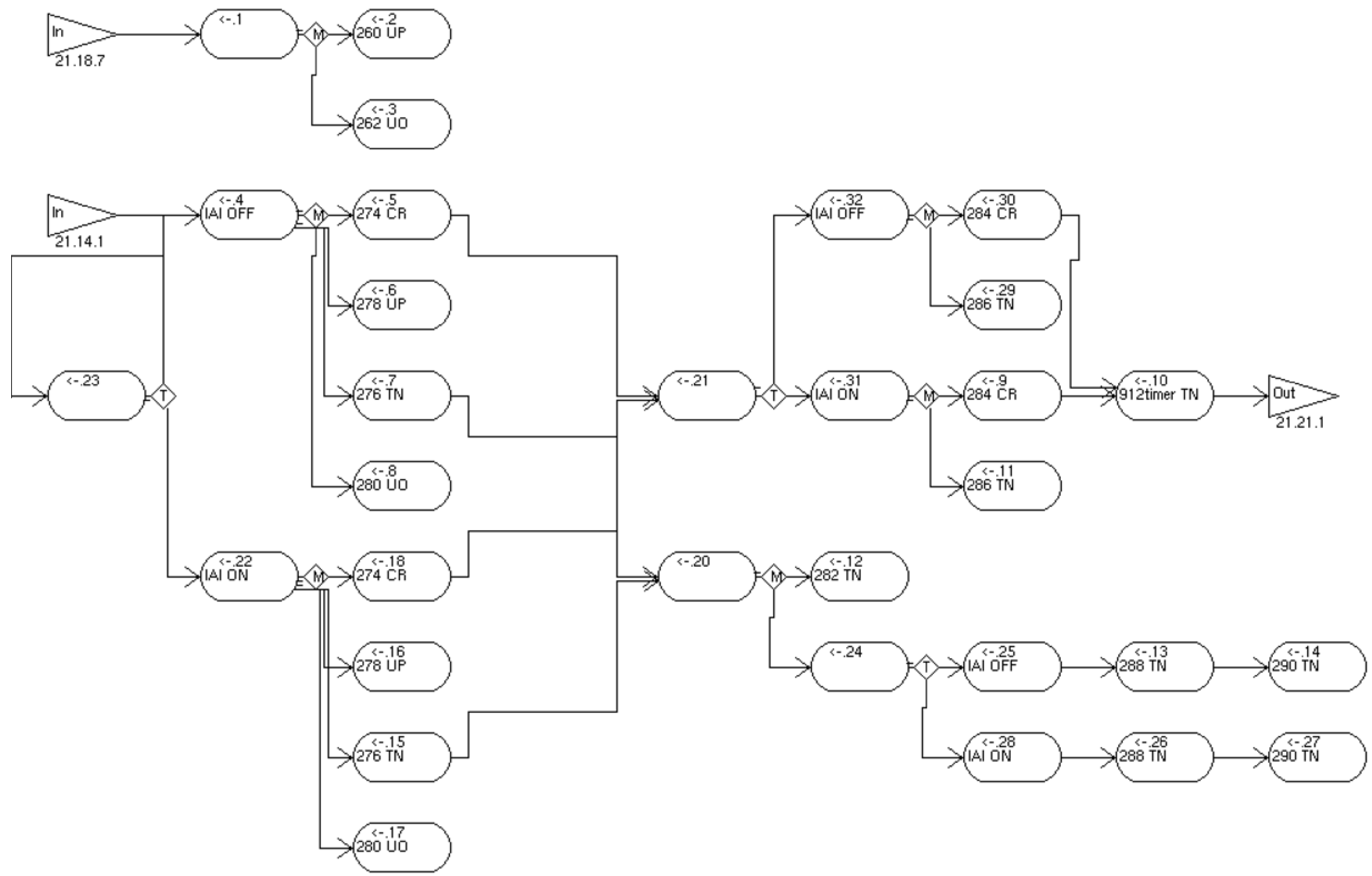


Figure F-40 Part 2 – Goal 260 ... CP140 on final run for deployment of Mini UAV 1

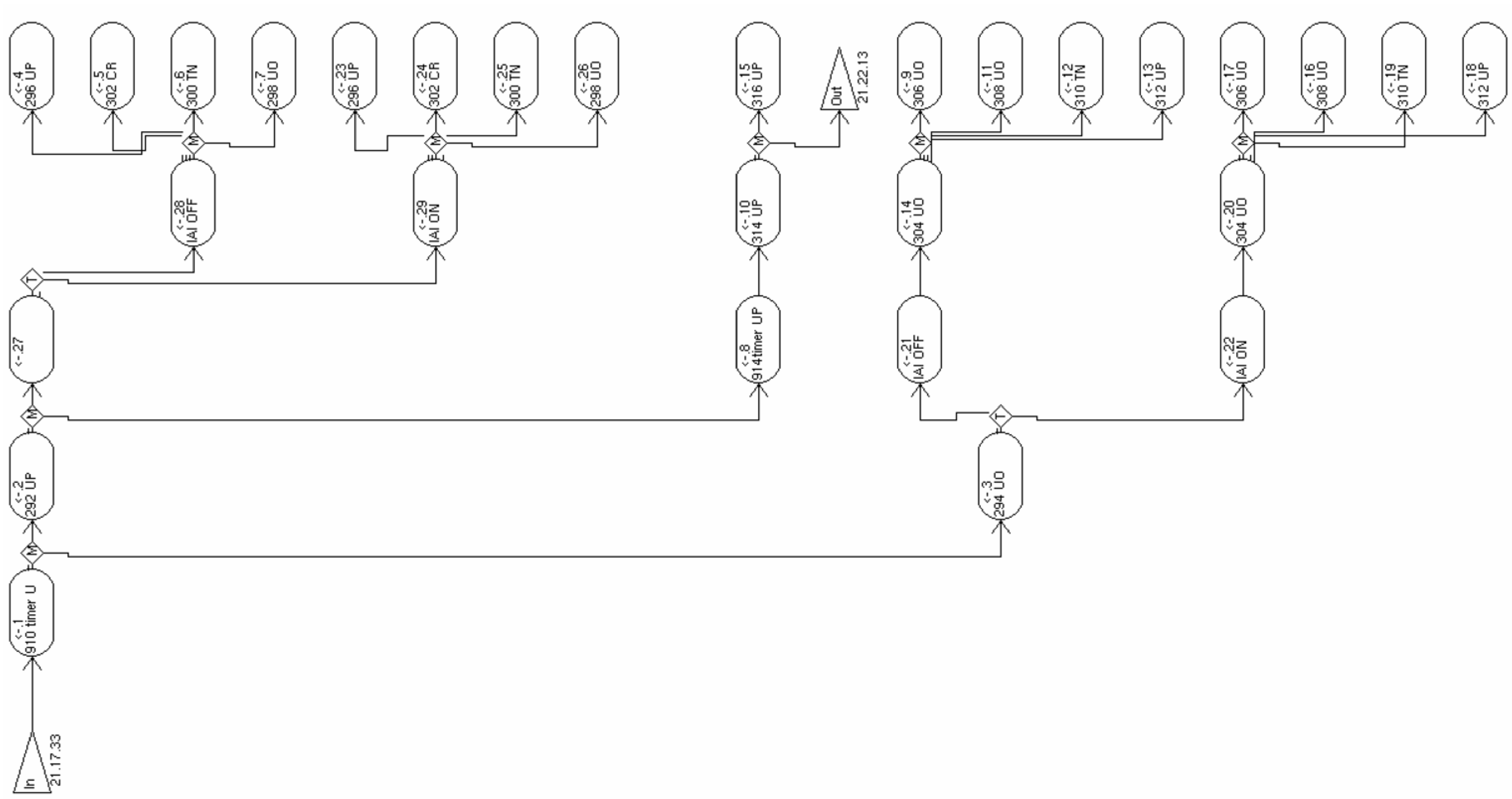


Figure F-41 Part 2 – Goal 292 ... VTUAV 1 has commenced EO Rig of Boat 1

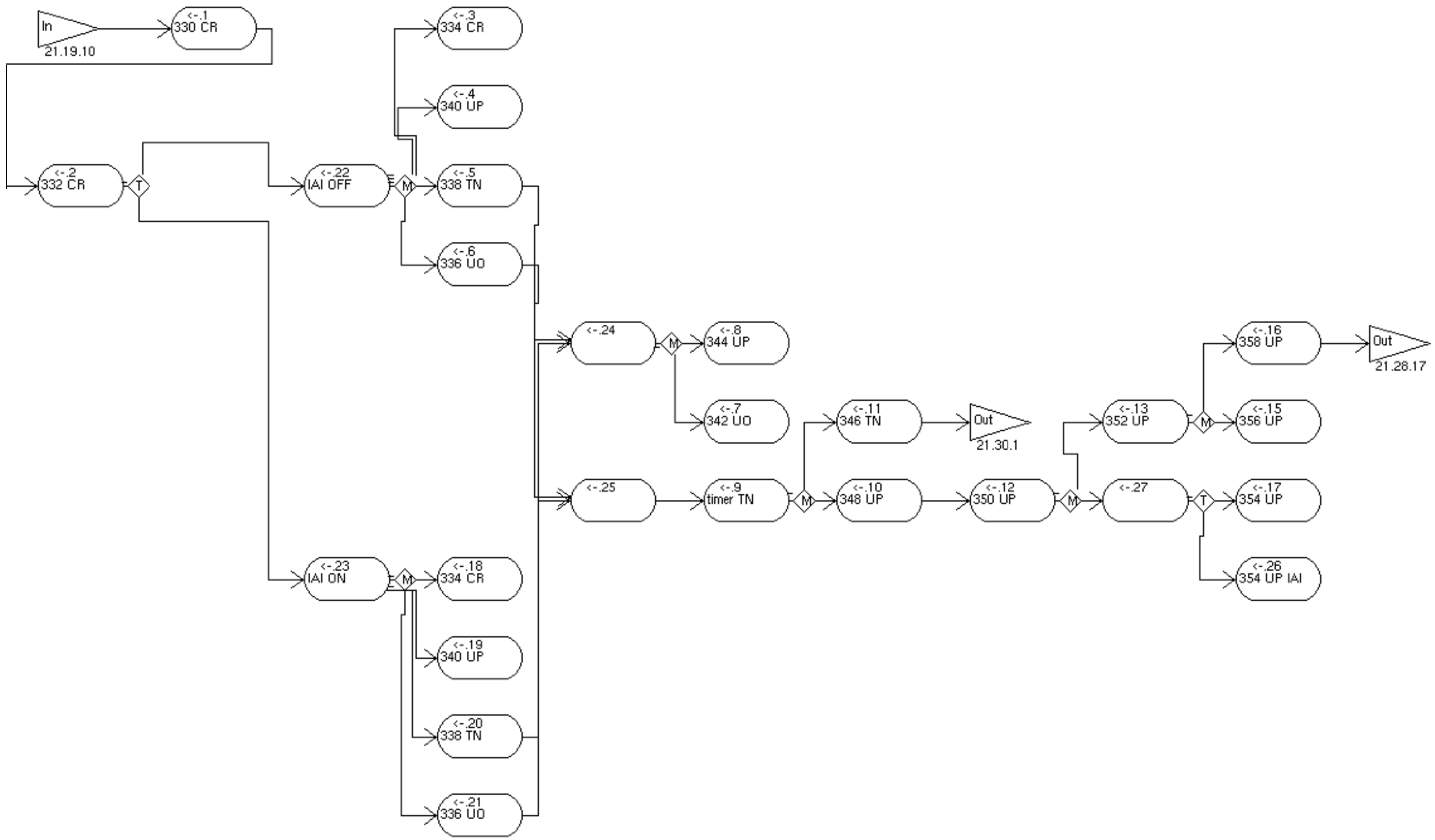


Figure F-42 Part 2 – Goal 330 ... Mini UAV 1 is deployed

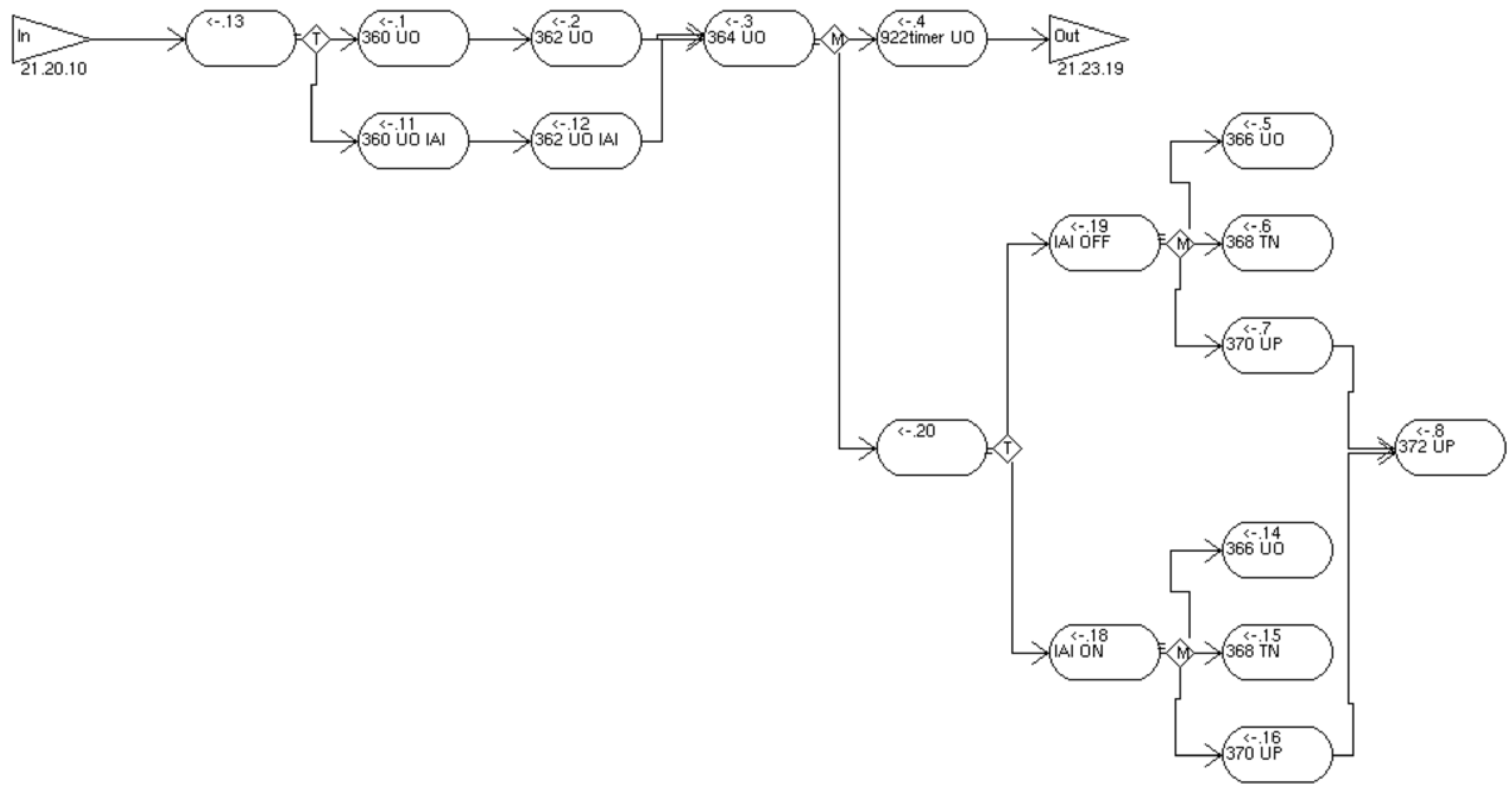


Figure F-43 Part 2 – Goal 360 ... Boat 1 is classified

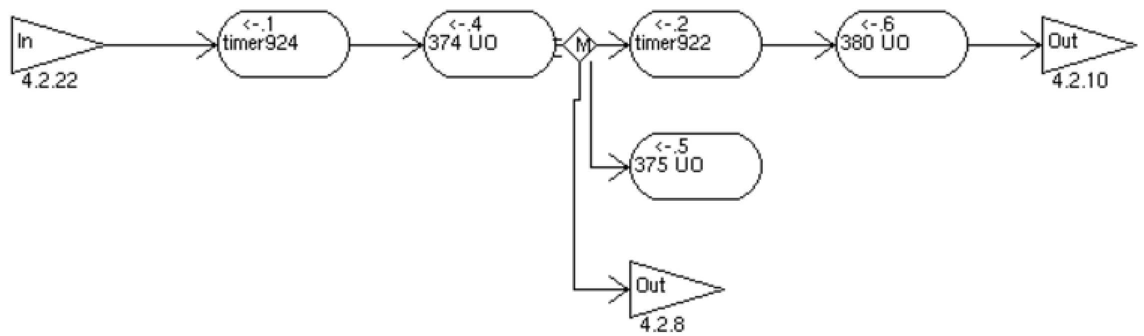


Figure F-44 Part 2 – Goal 374 ... MALE UAV ISAR imagery of Boat 3 analyzed

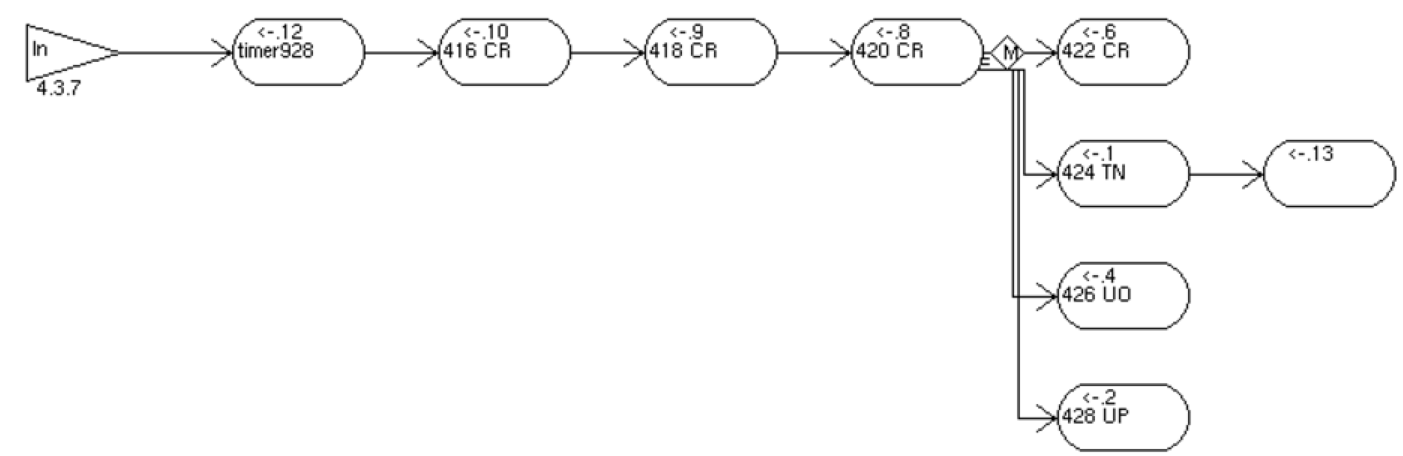


Figure F-46 Part 2 – Goal 416 ... Mini UAV is investigating Contact 4

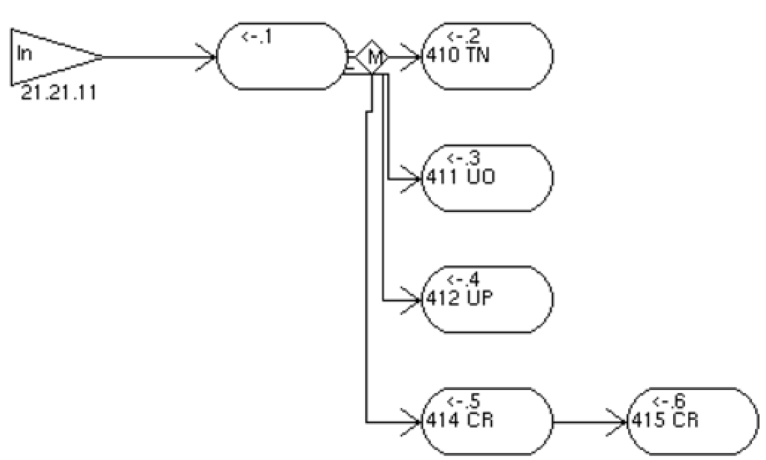


Figure F-45 Part 2 – Goal 410 ... CP140 is turning south to Contact 5

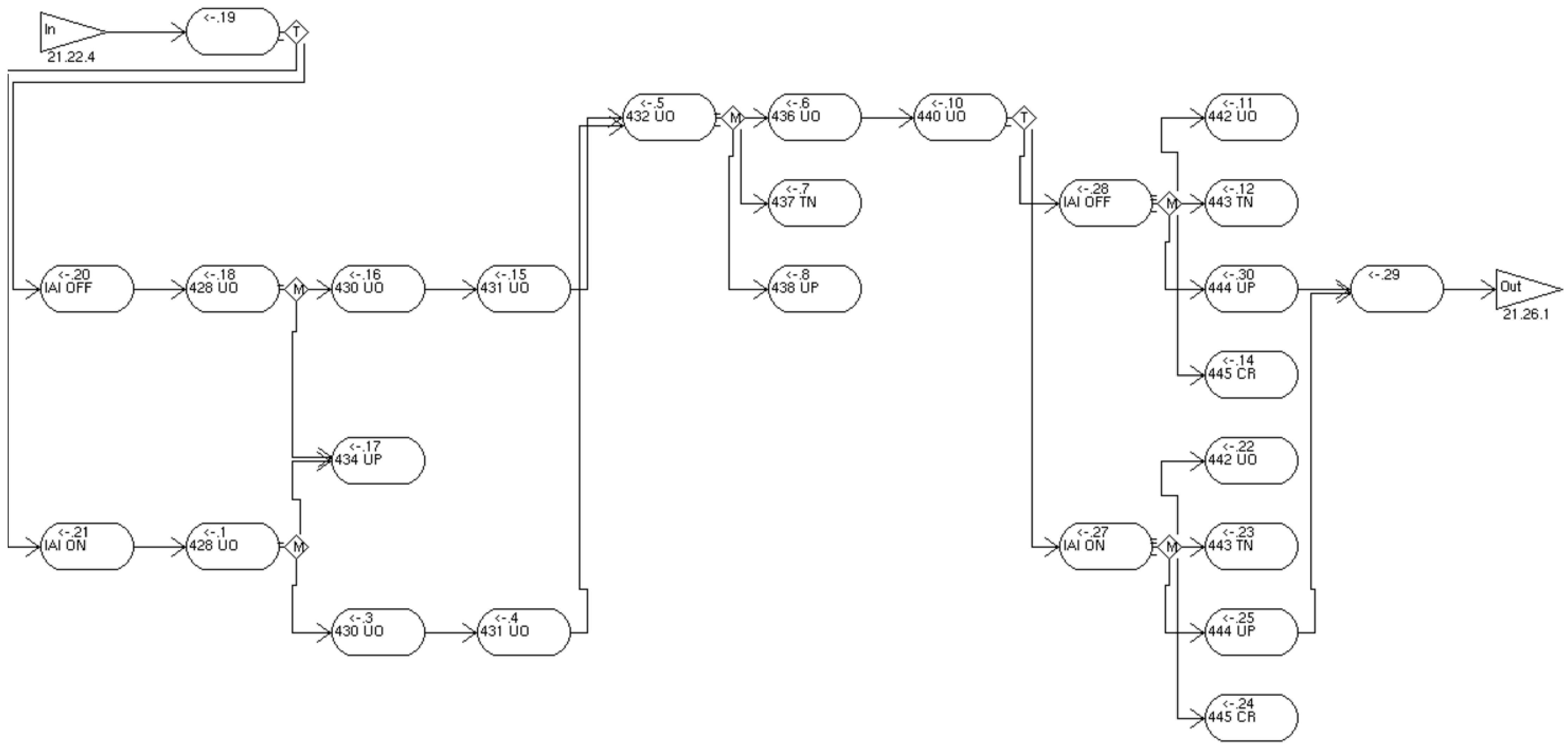


Figure F-47 Part 2 – Goal 428 … Boat 1 is identified and determined to be neutral

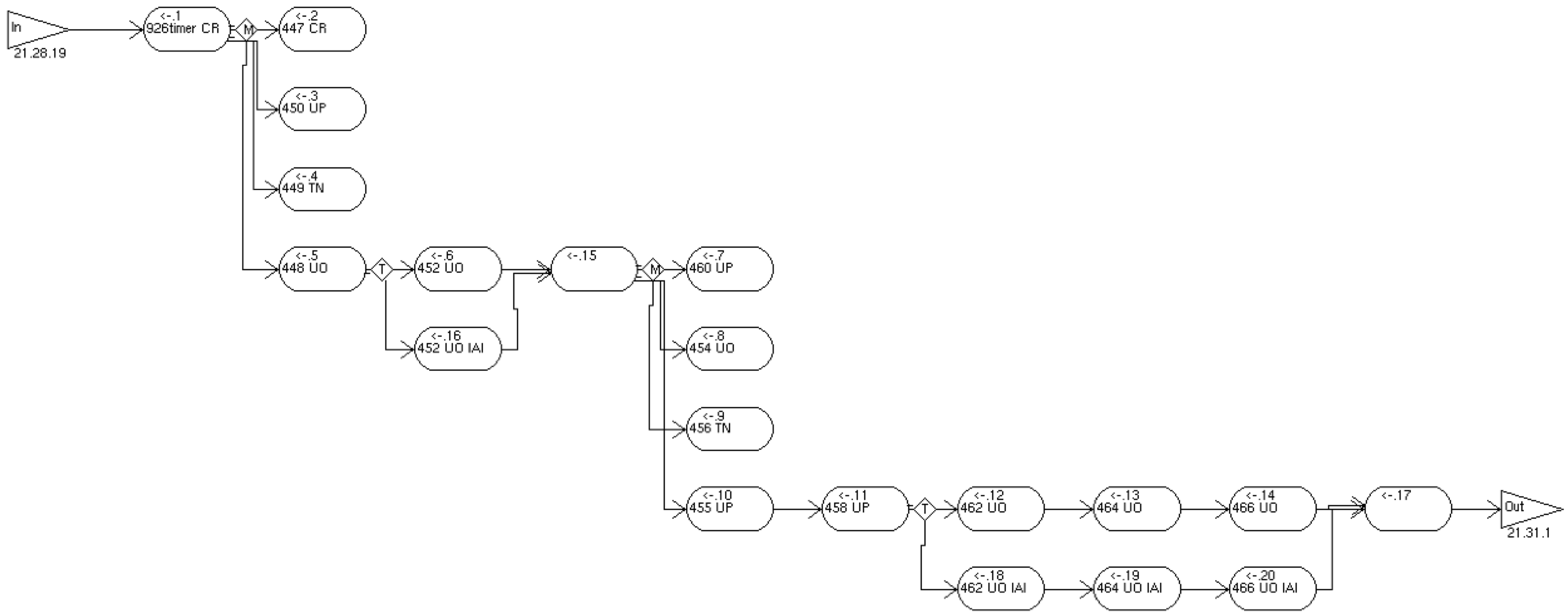


Figure F-48 Part 2 – Goal 447 … investigation of Contact 4 by Mini UAV 1 has commenced

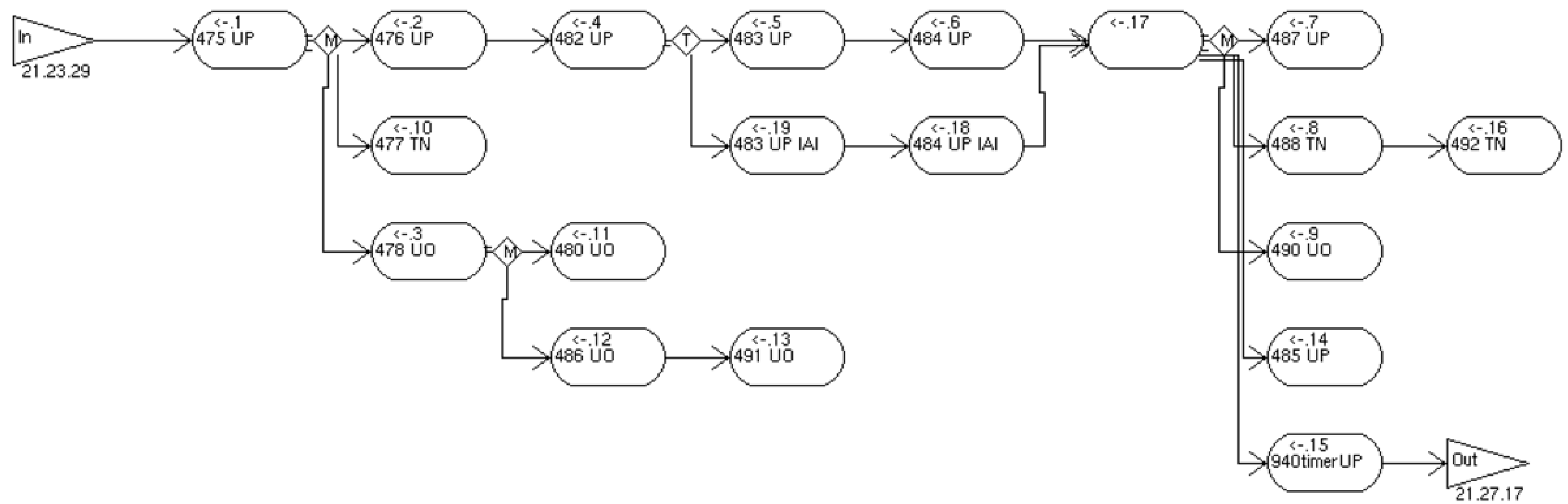


Figure F-49 Part 2 – Goal 475 … plan for approaching Boat 2 is complete

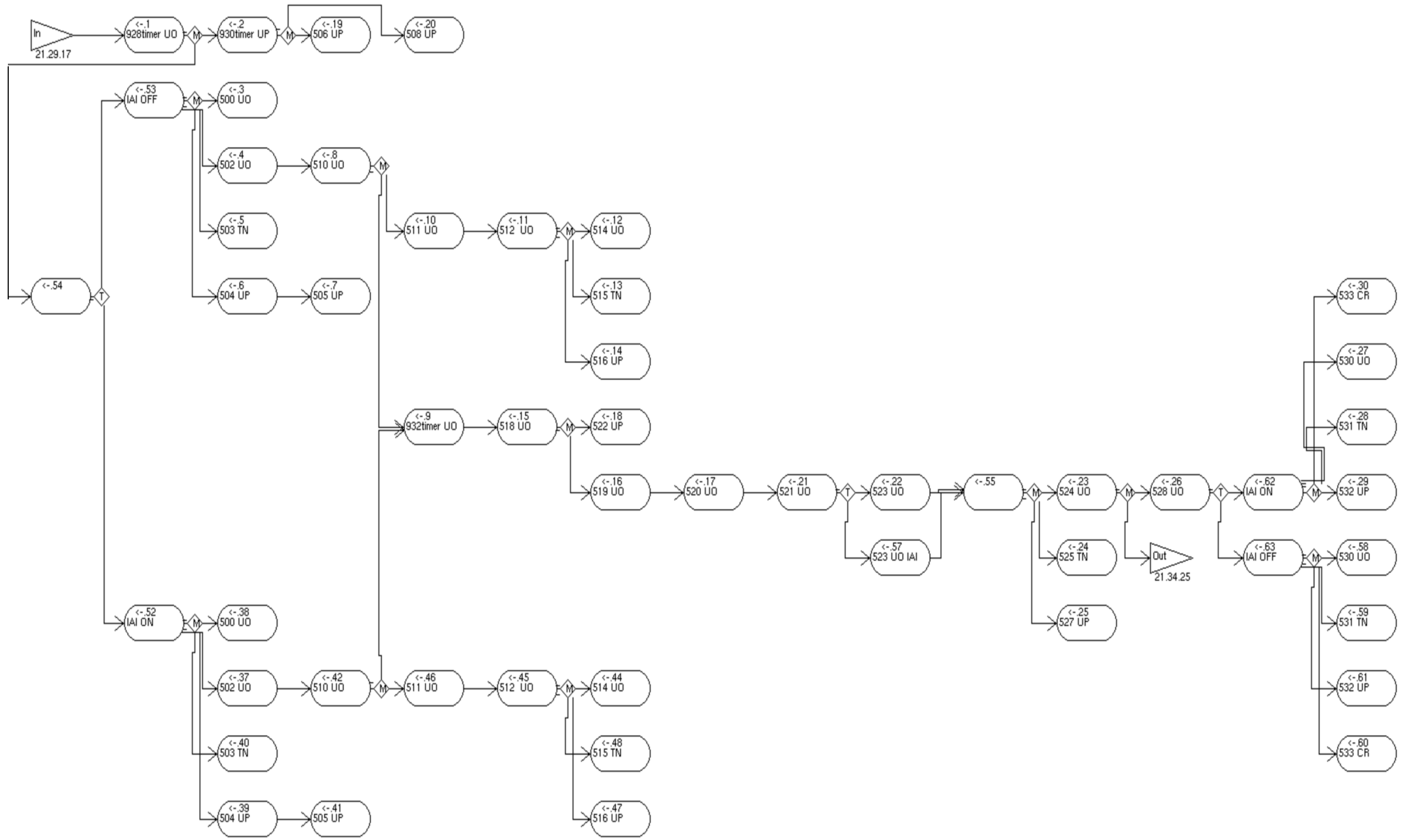


Figure F-50 Part 2 – Goal 500 ... identity of Contact 4 is determined using Mini UAV 1

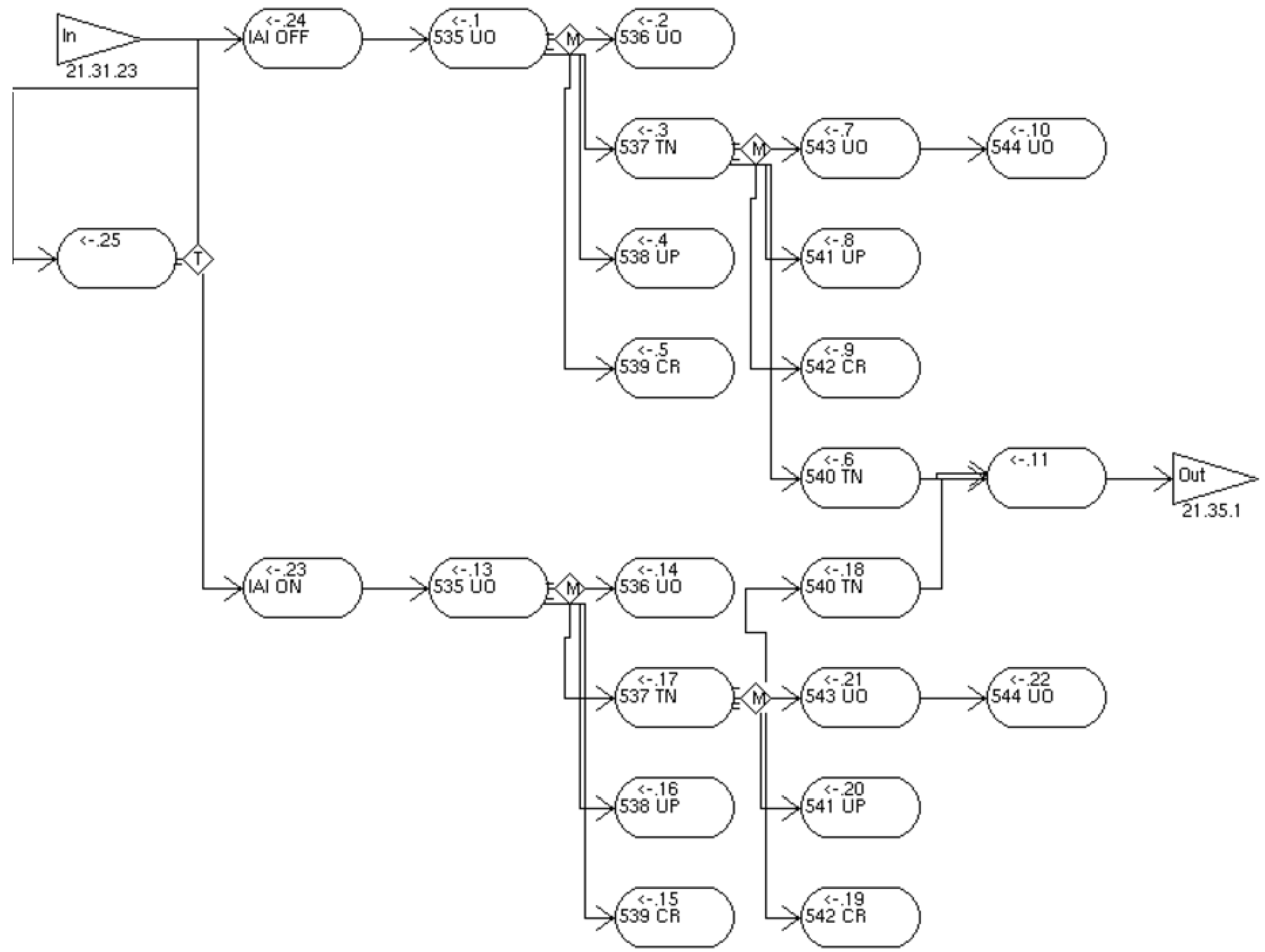


Figure F-51 Part 2 – Goal 535 ... illegal fishing activities of Contact 4 are reported

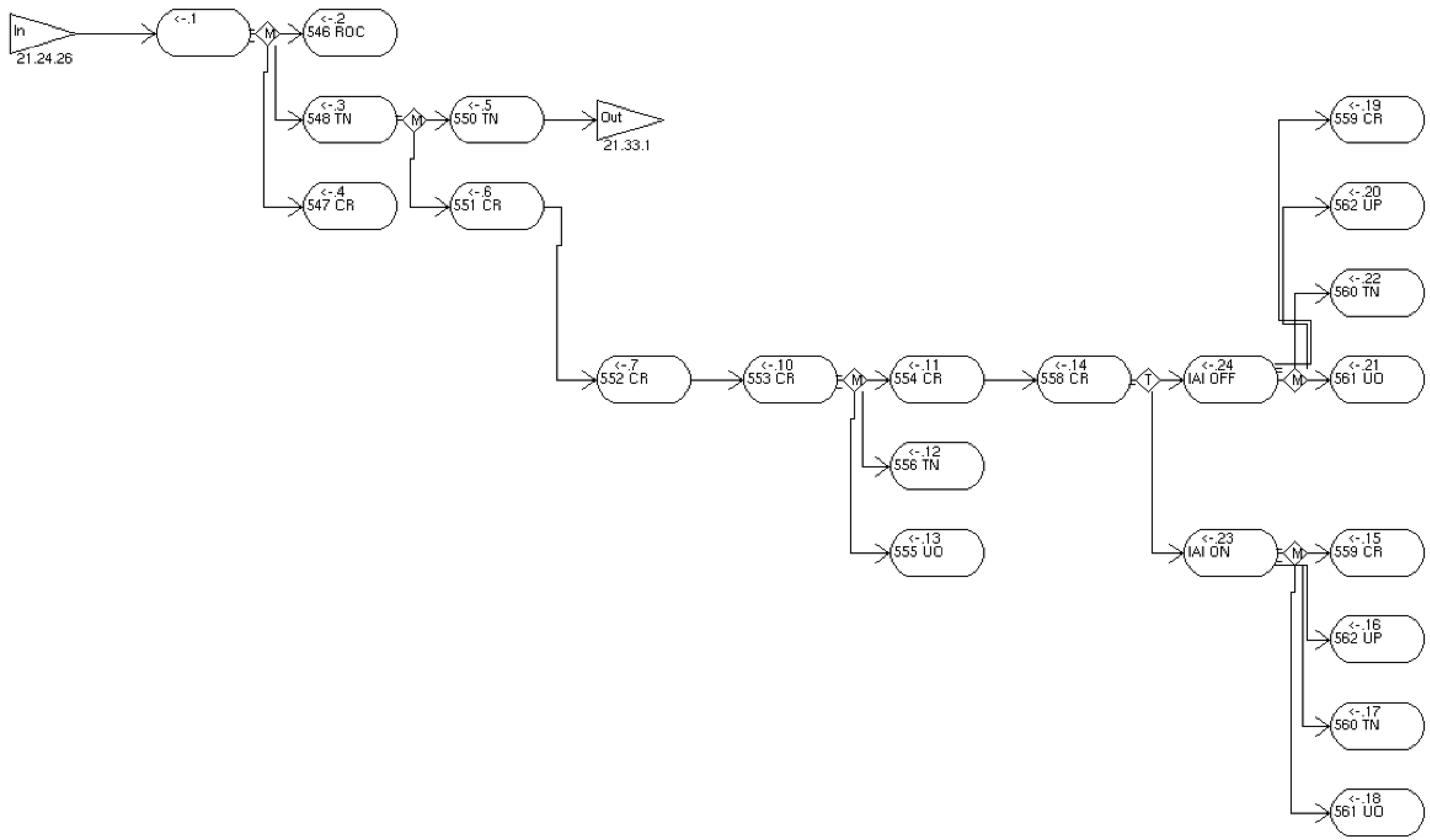


Figure F-52 Part 2 – Goal 546 ... Boat 3 is classified using the ISAR imagery from MALE UAV

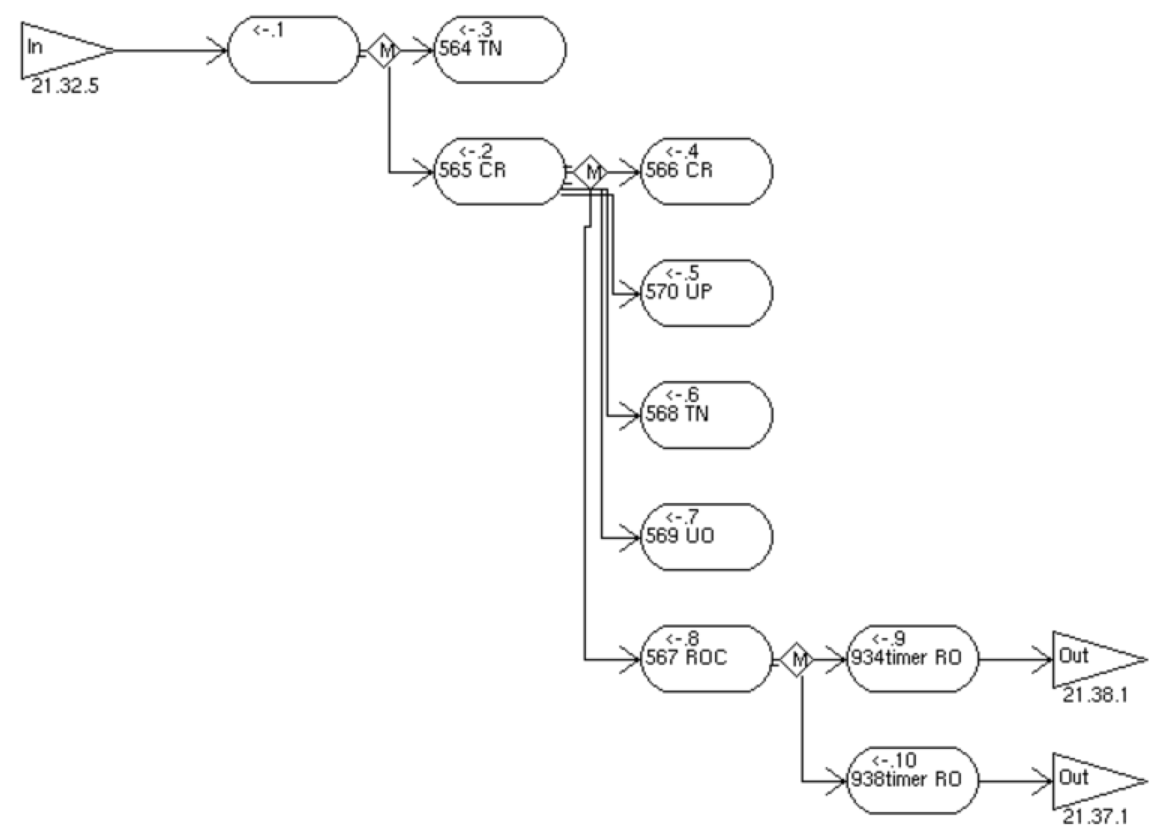


Figure F-53 Part 2 – Goal 564 ... MALE UAV is tasked to conduct ISAR imaging of Contact 3

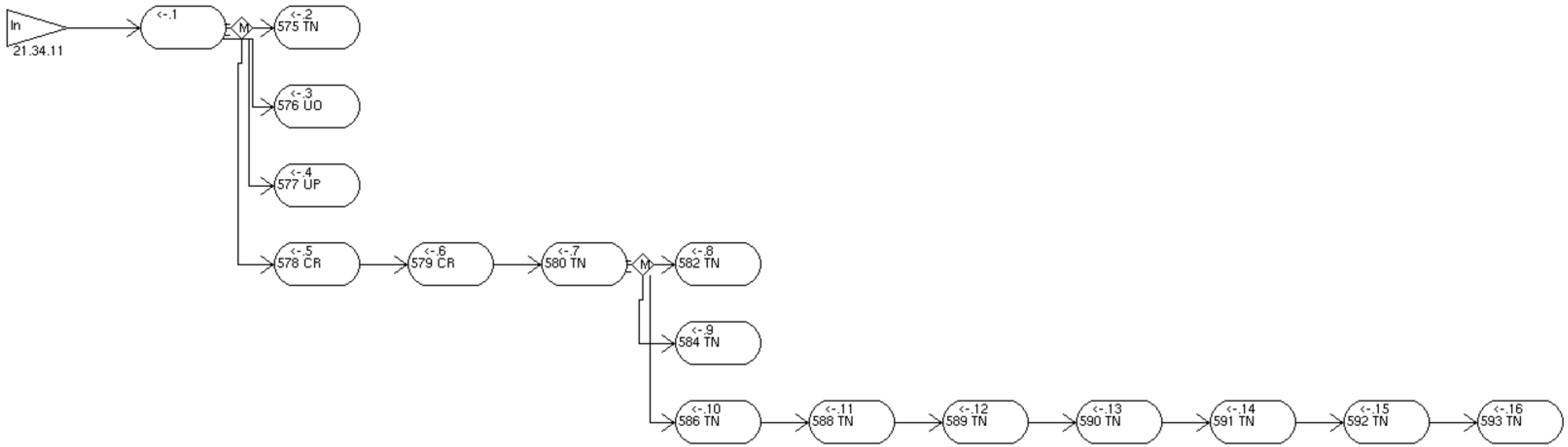


Figure F-54 Part 2 – Goal 575 ... activity of known contacts in the area

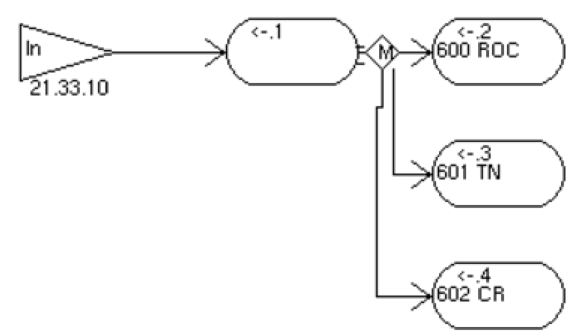


Figure F-55 Part 2 – Goal 600 ... message regarding the location of the operation area for VTUAV 2

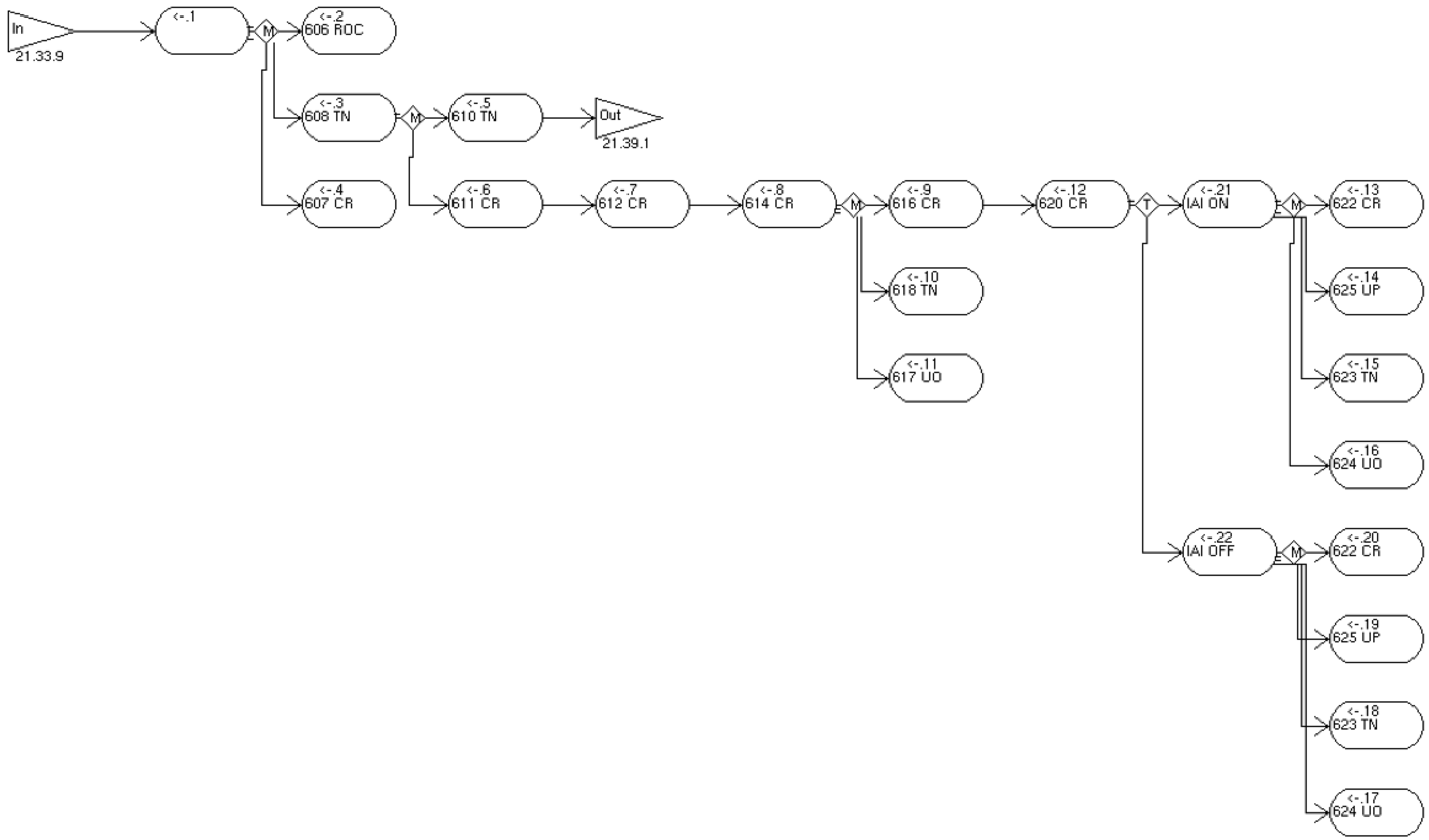


Figure F-56 Part 2 – Goal 606 ... Contact 3 is classified and determined to be neutral

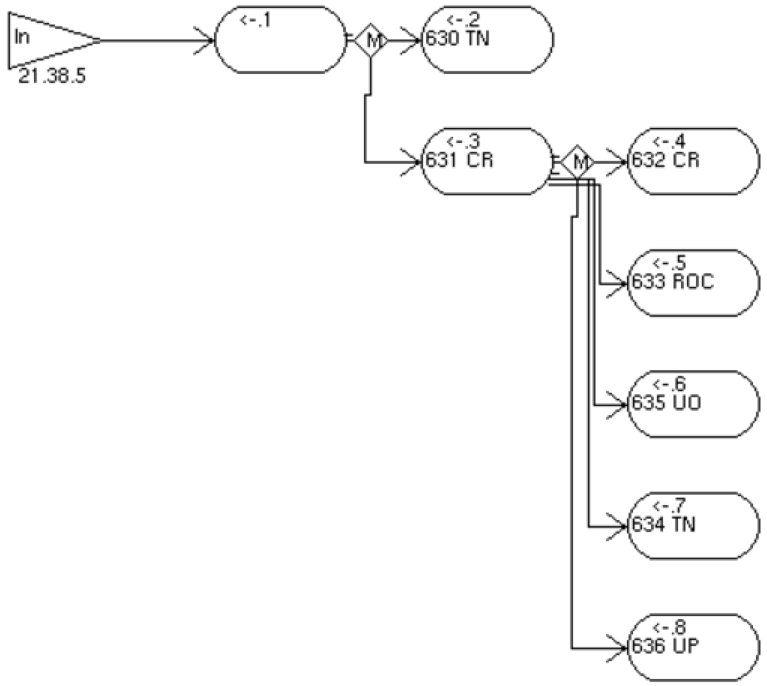


Figure F-57 Part 2 – Goal 630 ... MALE UAV is tasked to conduct ISAR imaging of Boat 2

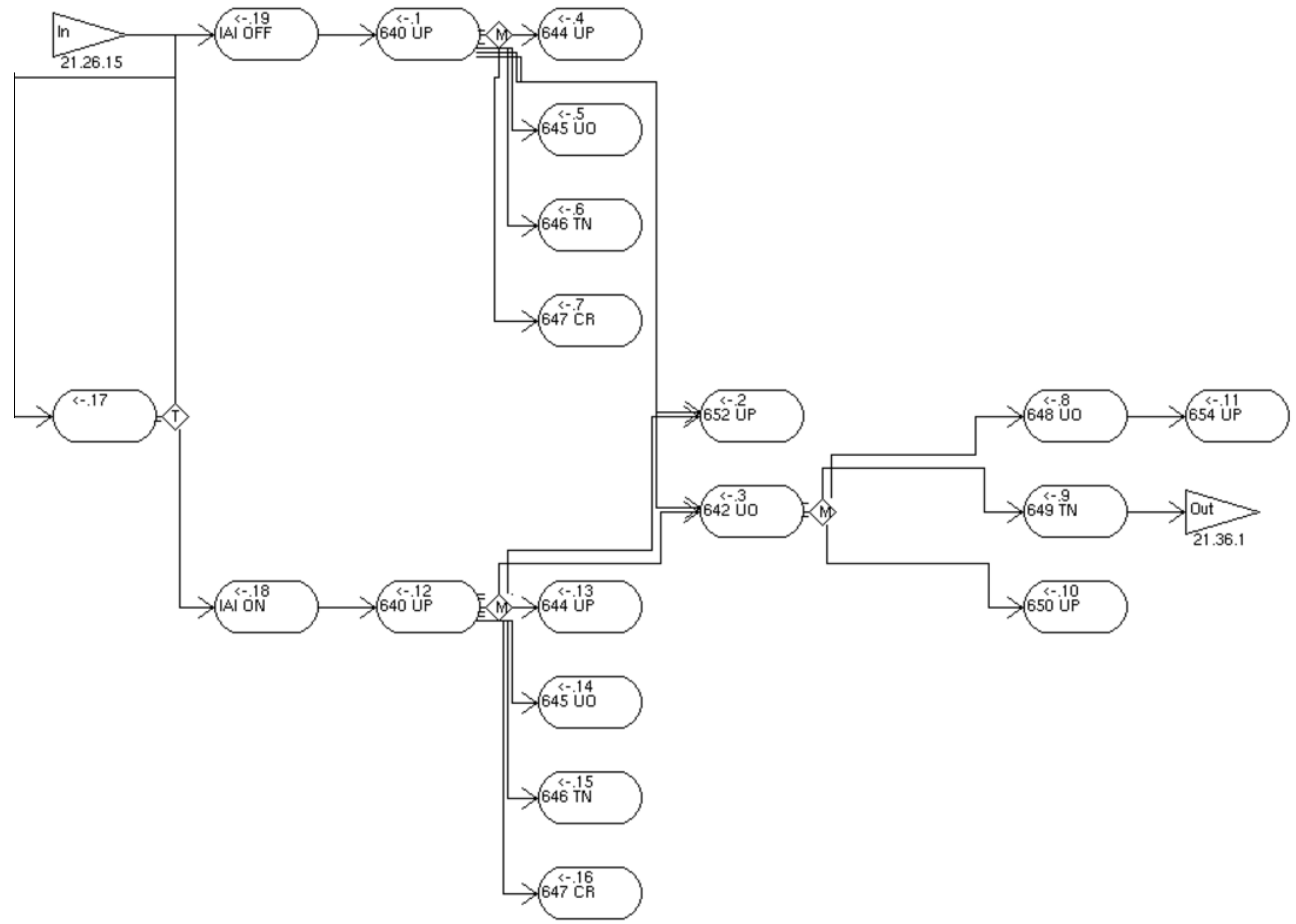


Figure F-59 Part 2 – Goal 640 ... VTUAV 1 is approaching Boat 2 and preparing for EO Rig of boat

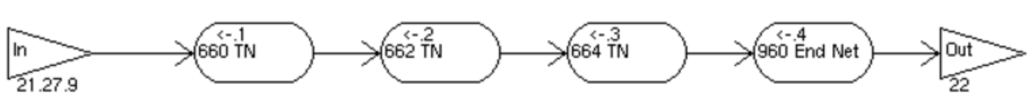


Figure F-58 Part 2 – Goal 660 ... wide search for possible terrorist vessel is initiated

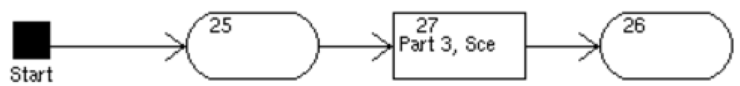


Figure F-60 Part 3 of Scenario – Last Twenty Minutes

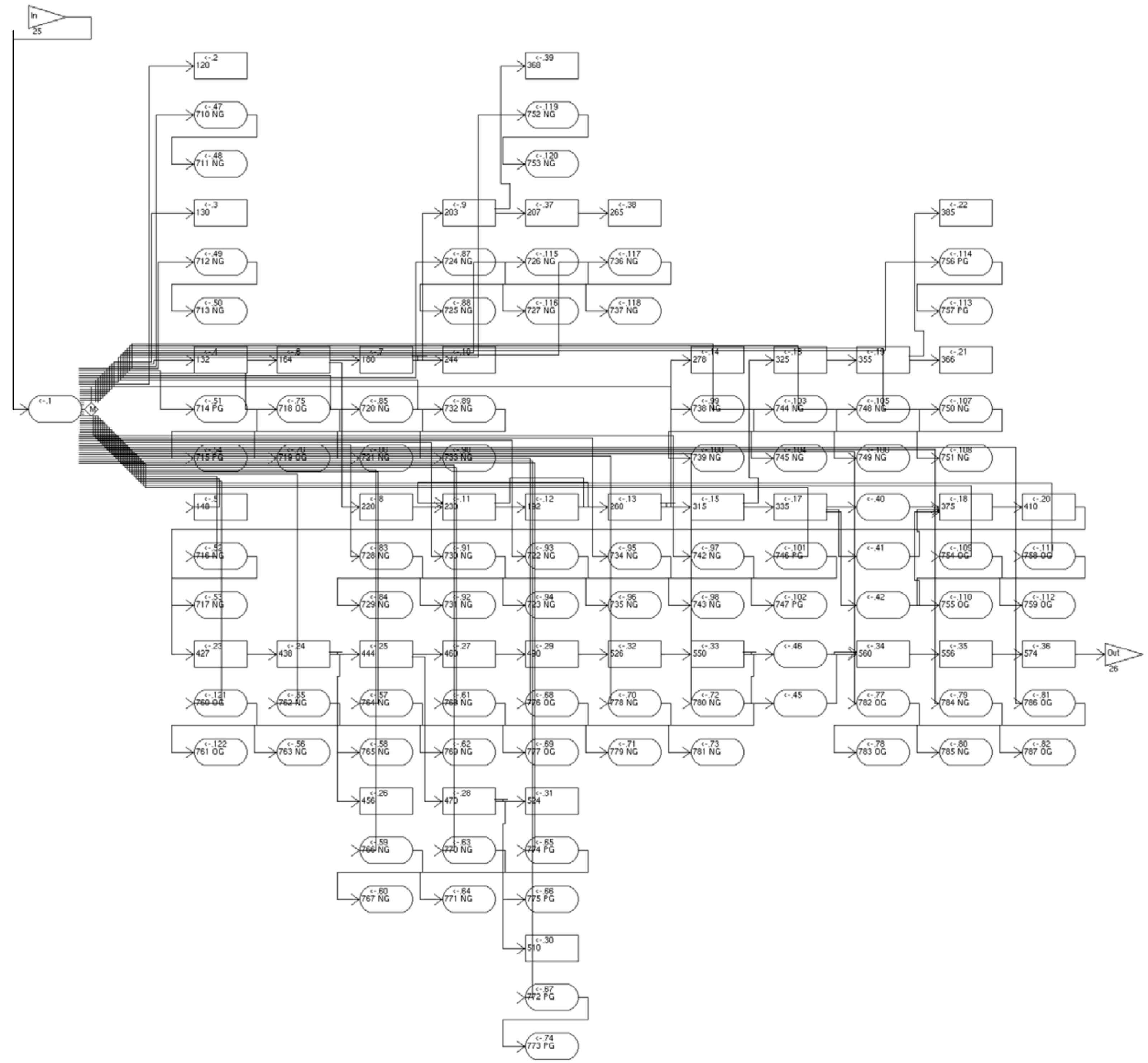


Figure F-61 Part 3 of Scenario – Last Twenty Minutes

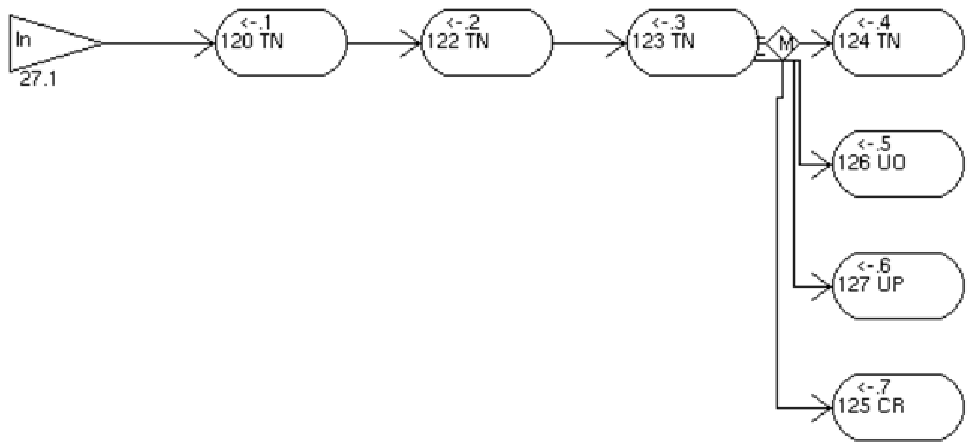


Figure F-62 Part 3 – Goal 120 ... plan to utilize available assets developed

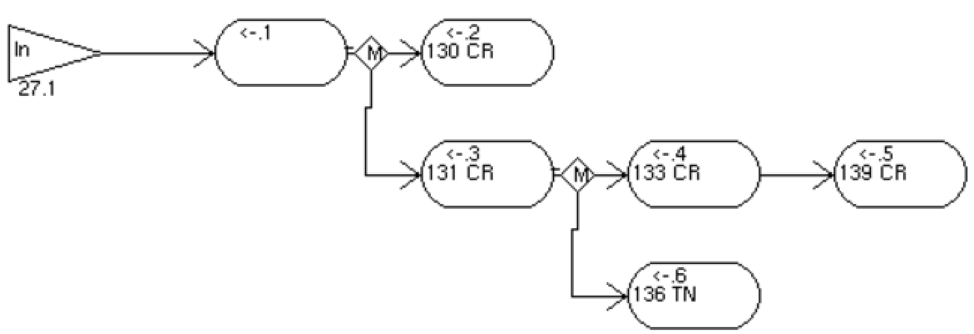


Figure F-63 Part 3 – Goal 130 ... CP140 is in level flight en route to Boat 2

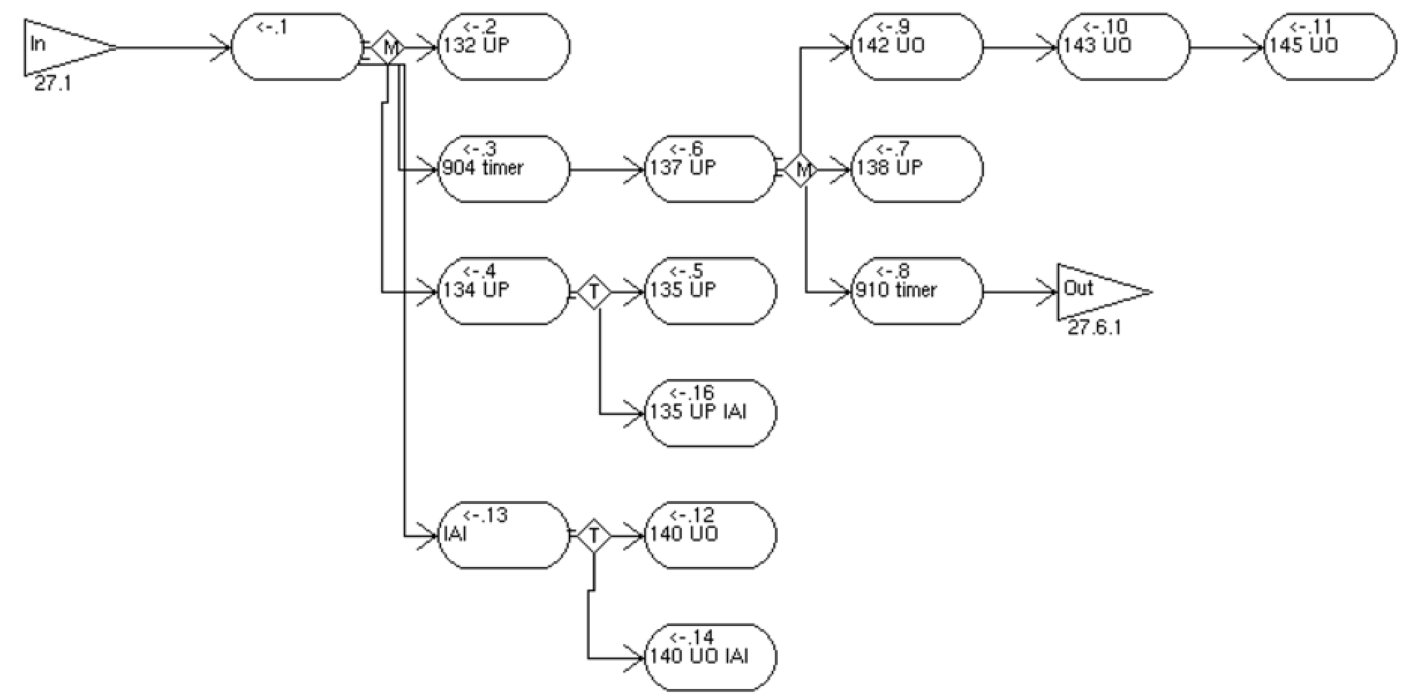


Figure F-64 Part 3 – Goal 132 ... VTUAV 1 is approaching Boat 2

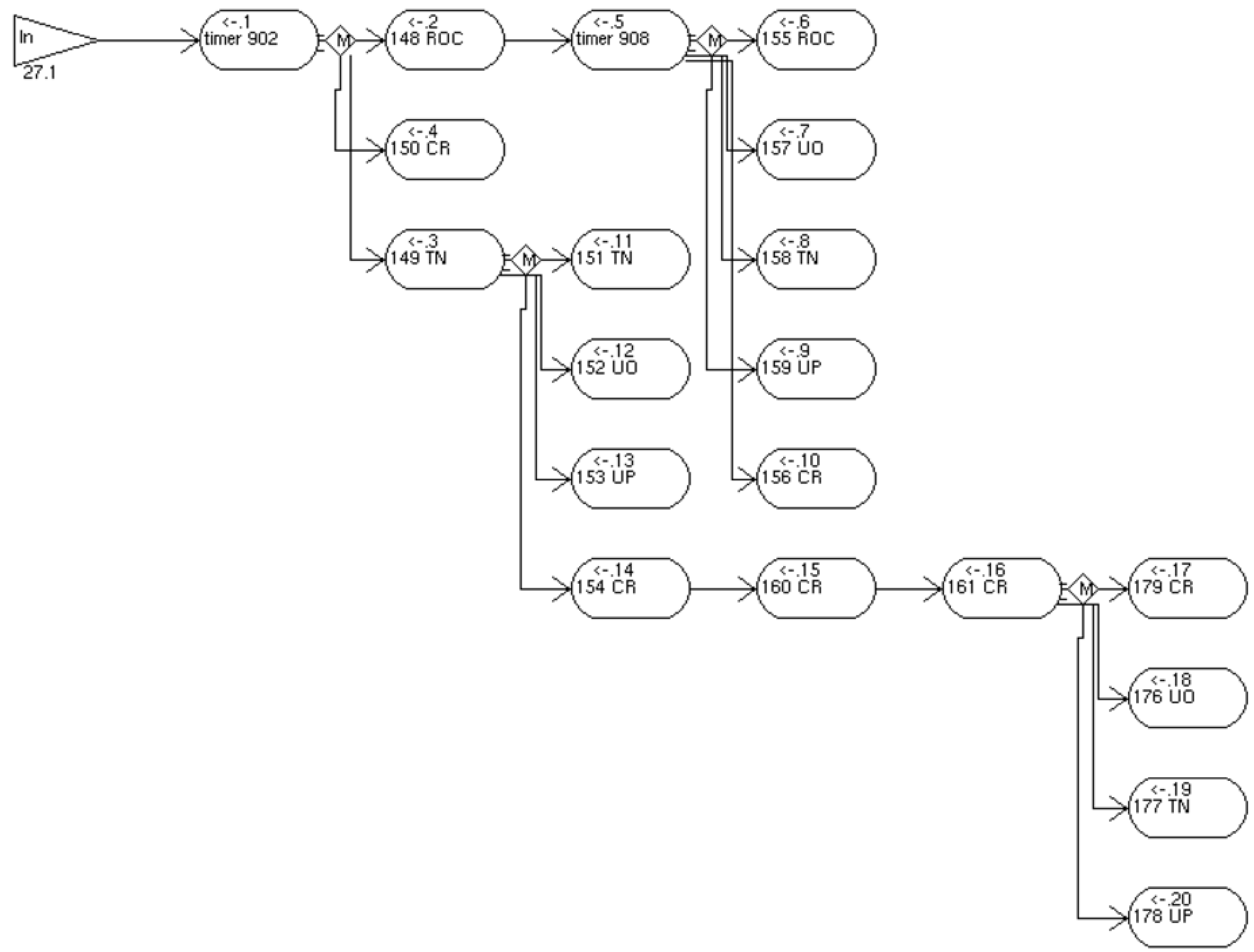


Figure F-65   Part 3 – Goal 148 ... ISAR imagery of Boat 2 is analyzed

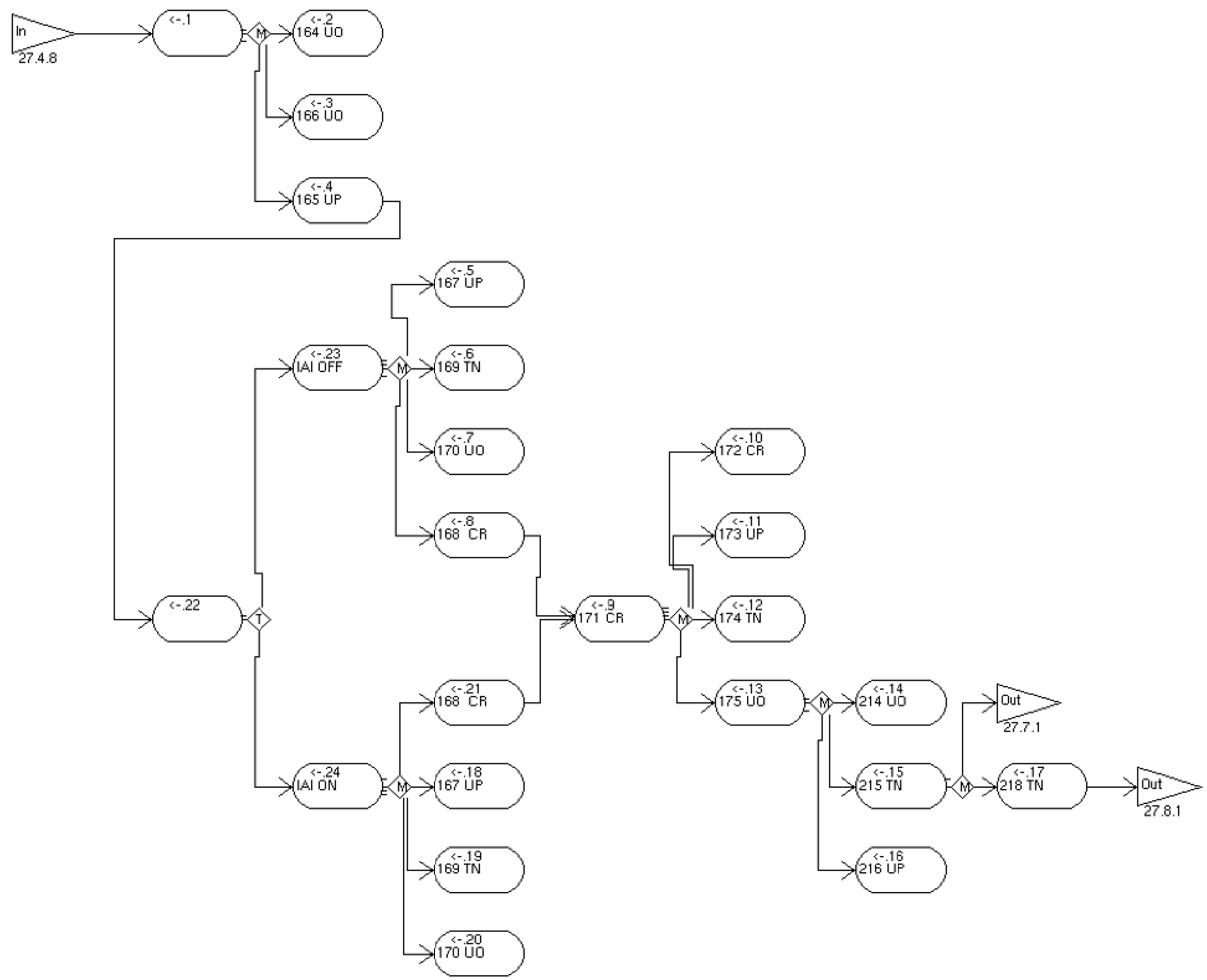


Figure F-66 Part 3 – Goal 164 ... operational viability of VTUAV

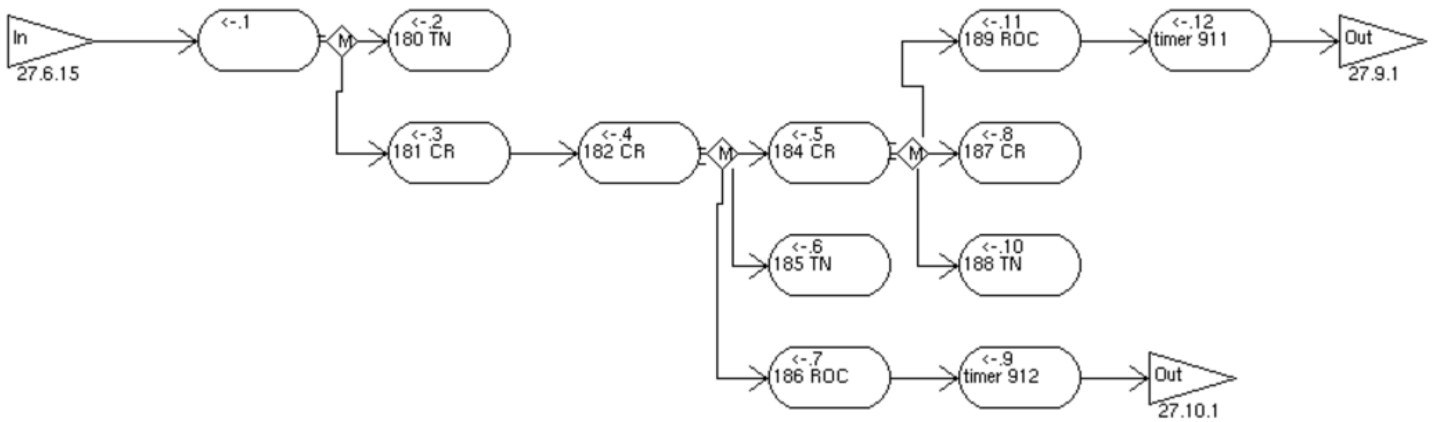


Figure F-67 Part 3 – Goal 180 ... SITEREPs are being sent

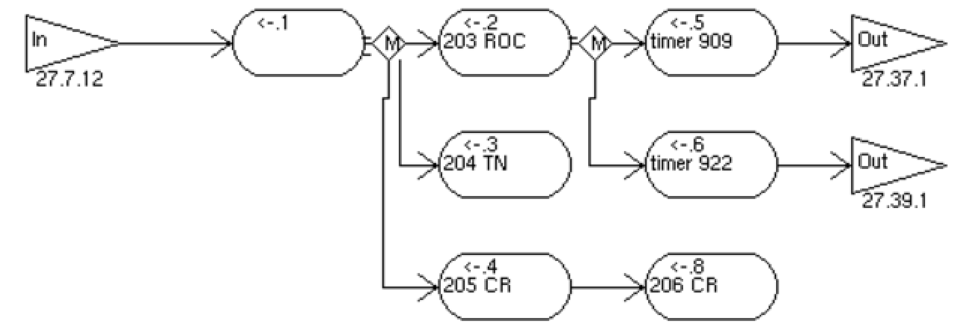


Figure F-69 Part 3 – Goal 203 ... message from MOC regarding CF188 tasking

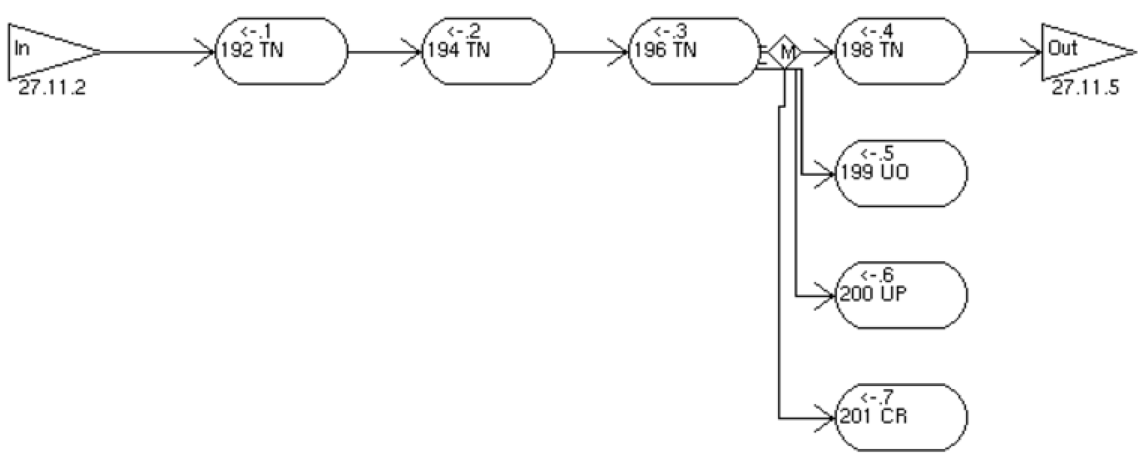


Figure F-68 Part 3 – Goal 192 ... decision made that CP140 should be the SAC

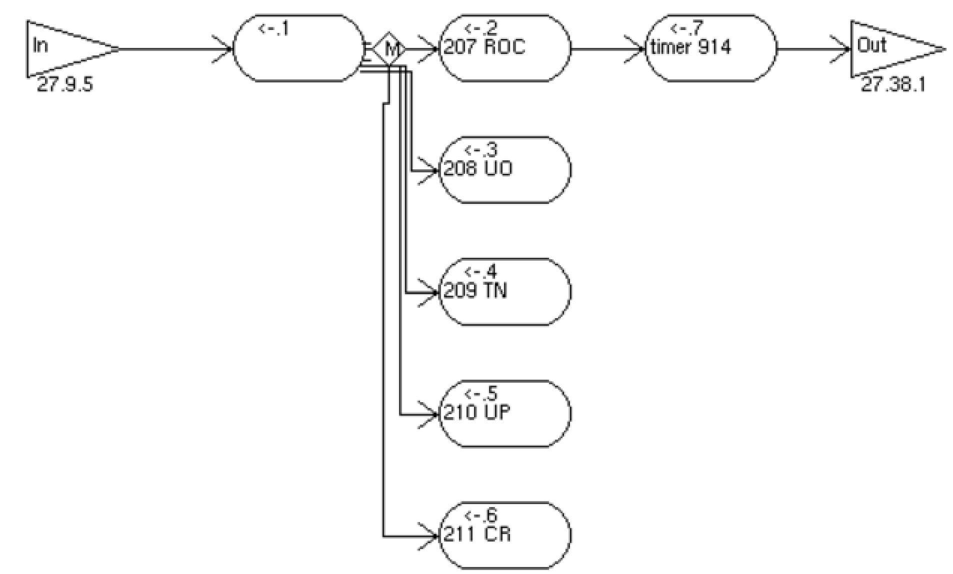


Figure F-70 Part 3 – Goal 207 ... message from CPF regarding VTUAV 2 handover

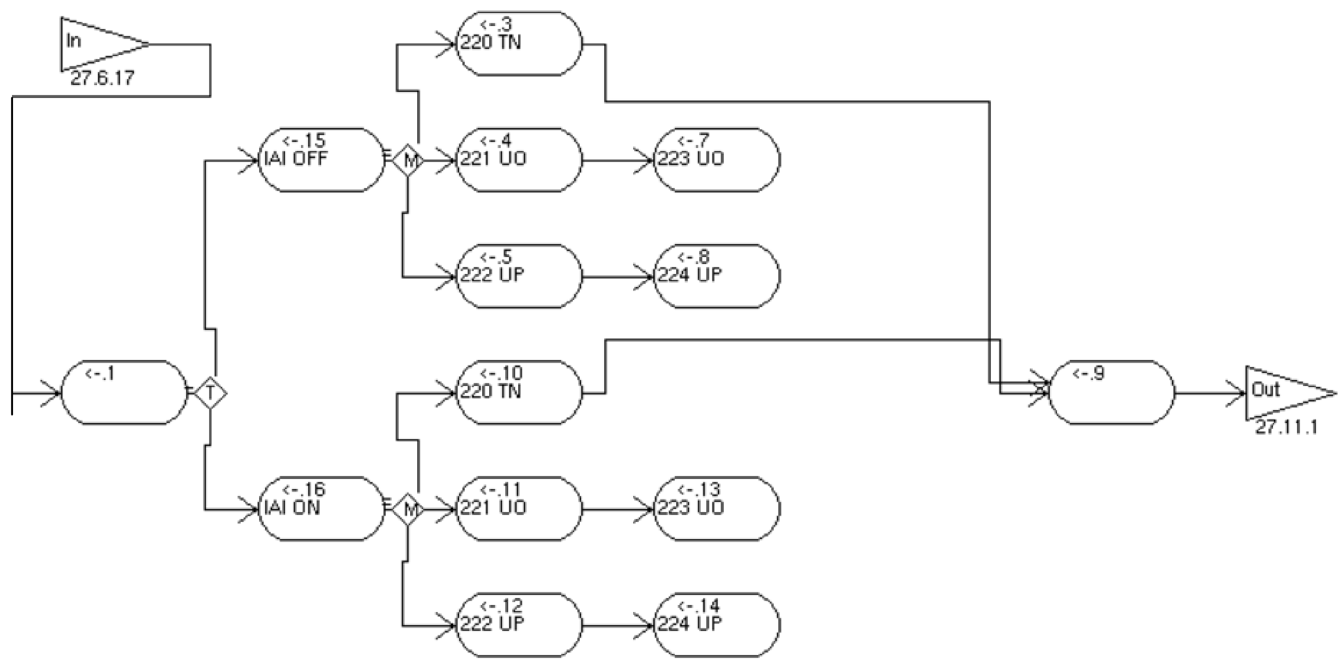


Figure F-71 Part 3 – Goal 220 ... Mini UAV 1 is terminated

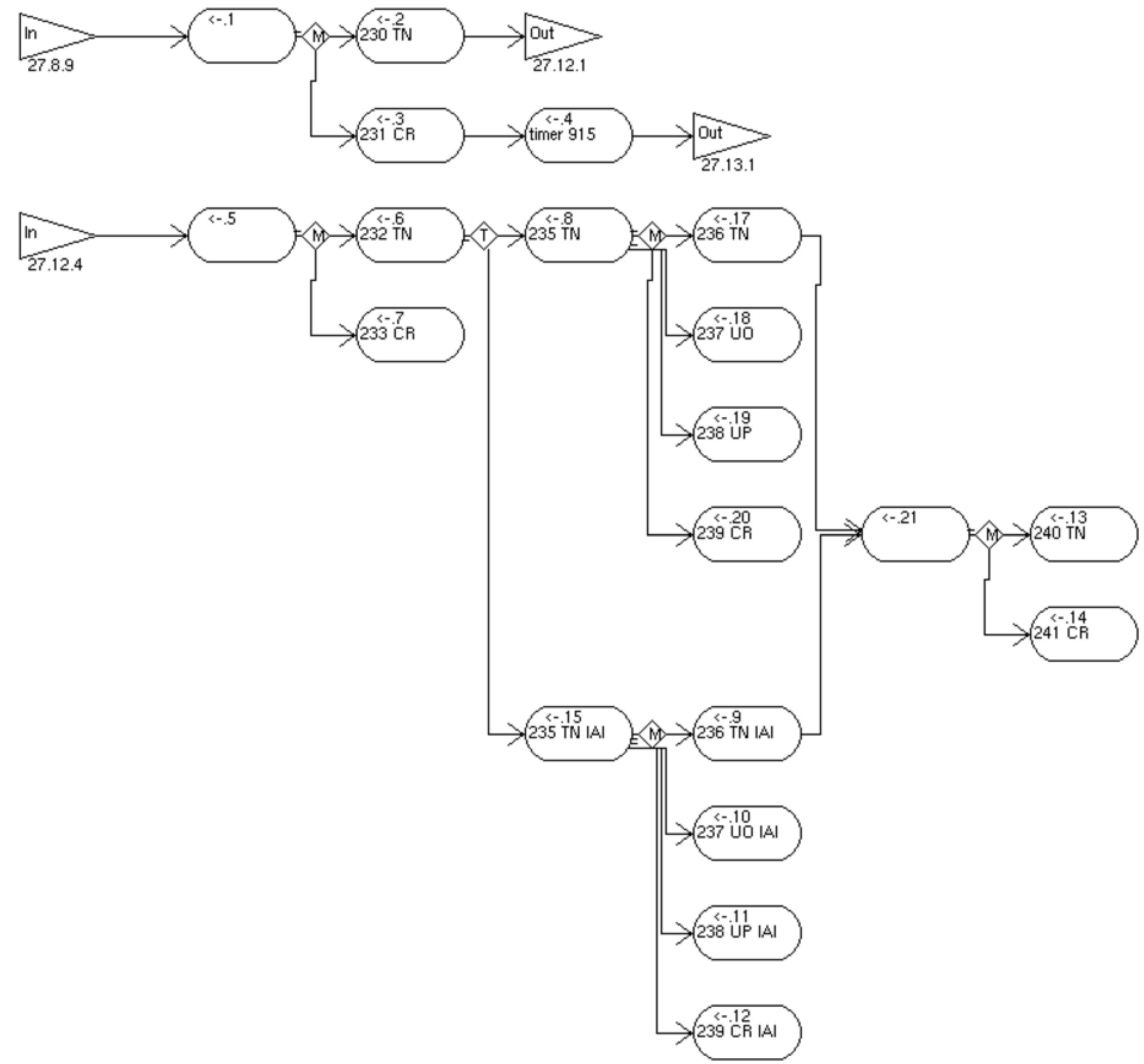


Figure F-72 Part 3 – Goal 230 ... crew is briefed on response to the loss of VTUAV 1

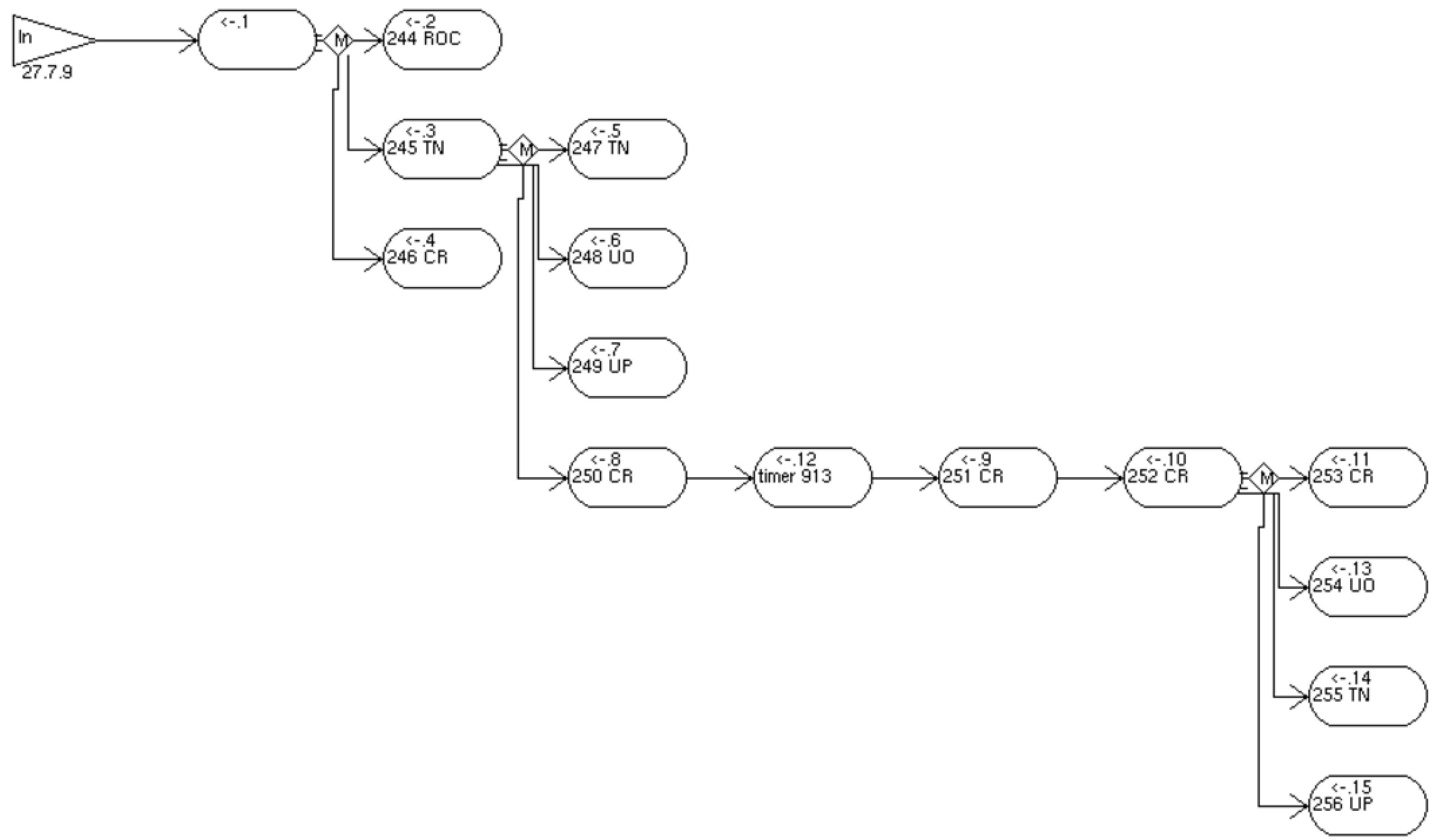


Figure F-73 Part 3 – Goal 244 ... new ISAR imagery of Boat 2 is downloaded and studied

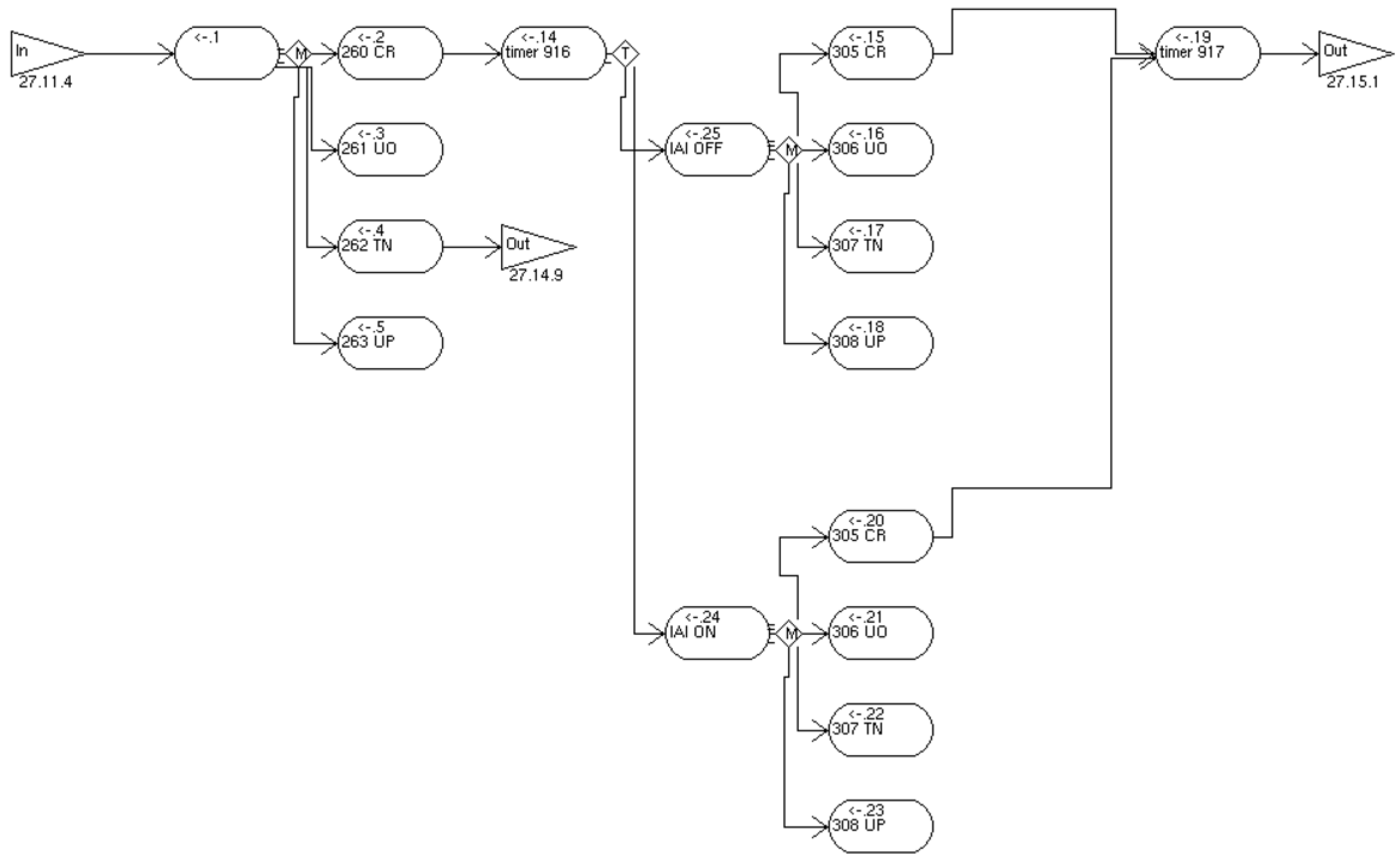


Figure F-74 Part 3 – Goal 260 ... CP140 is approaching Boat 2

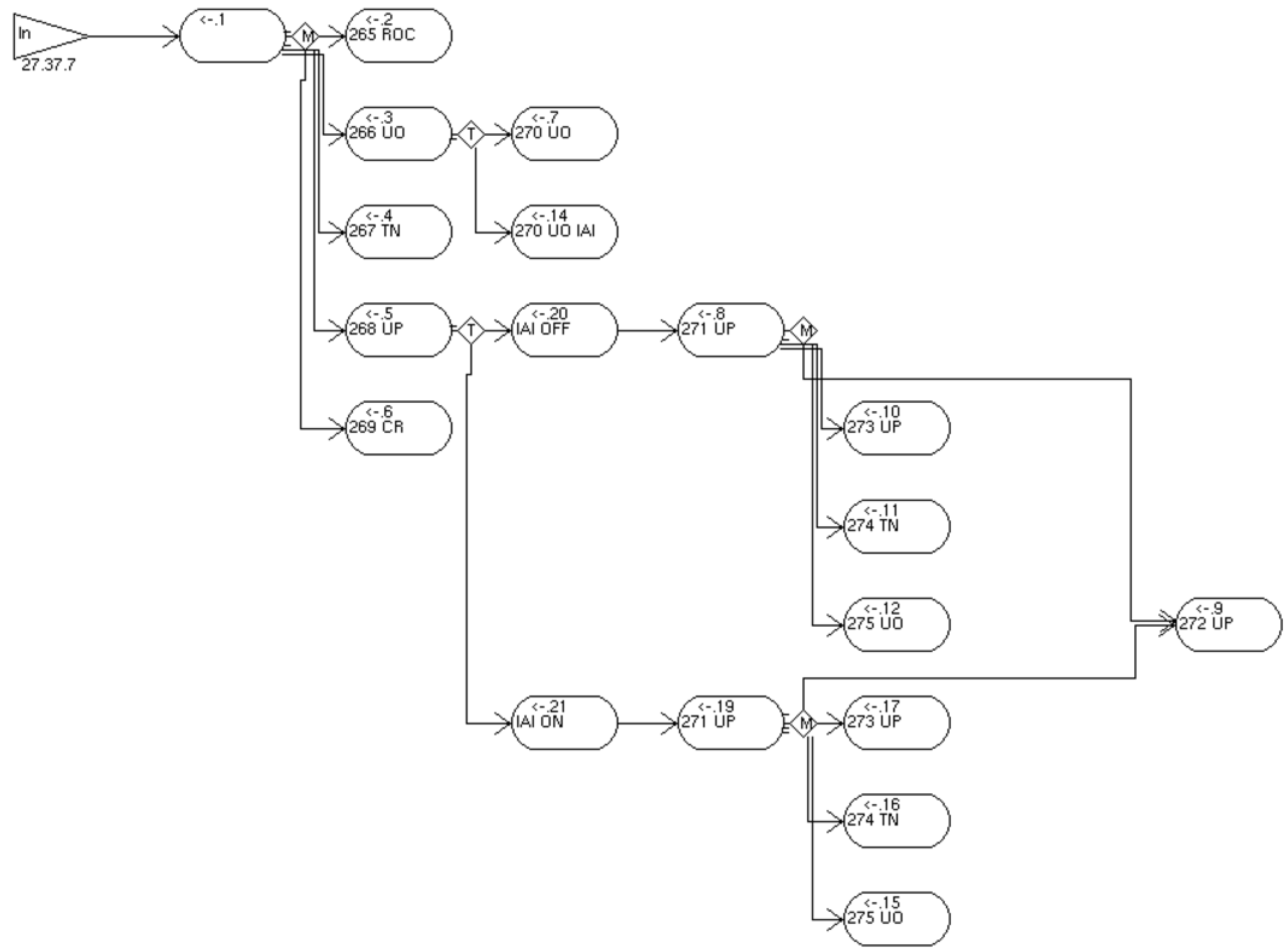


Figure F-75 Part 3 – Goal 265 ... handover of VTUAV 2 is completed

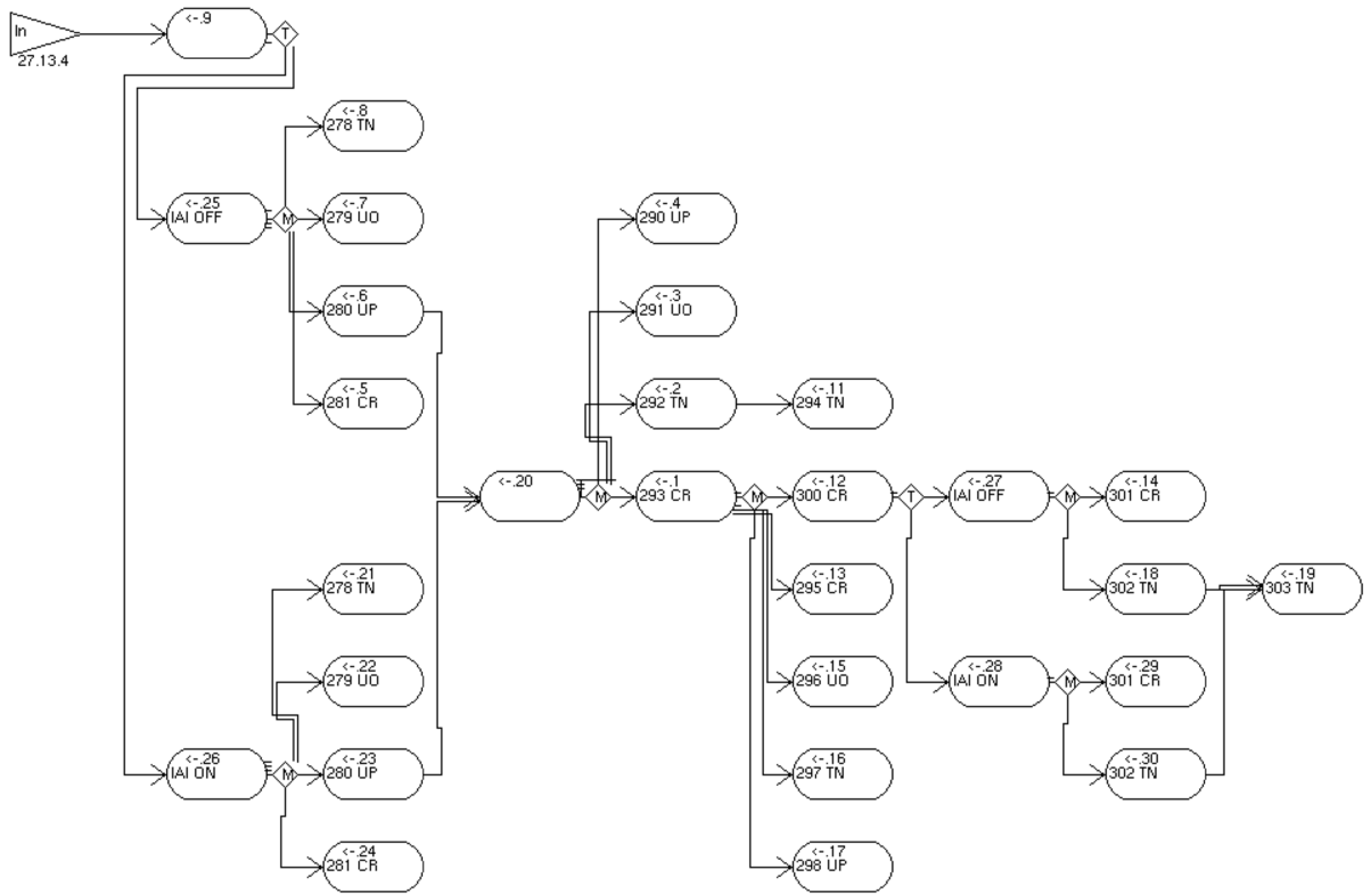


Figure F-76 Part 3 – Goal 278 ... Mini UAVs 2 to 5 are readied for launch

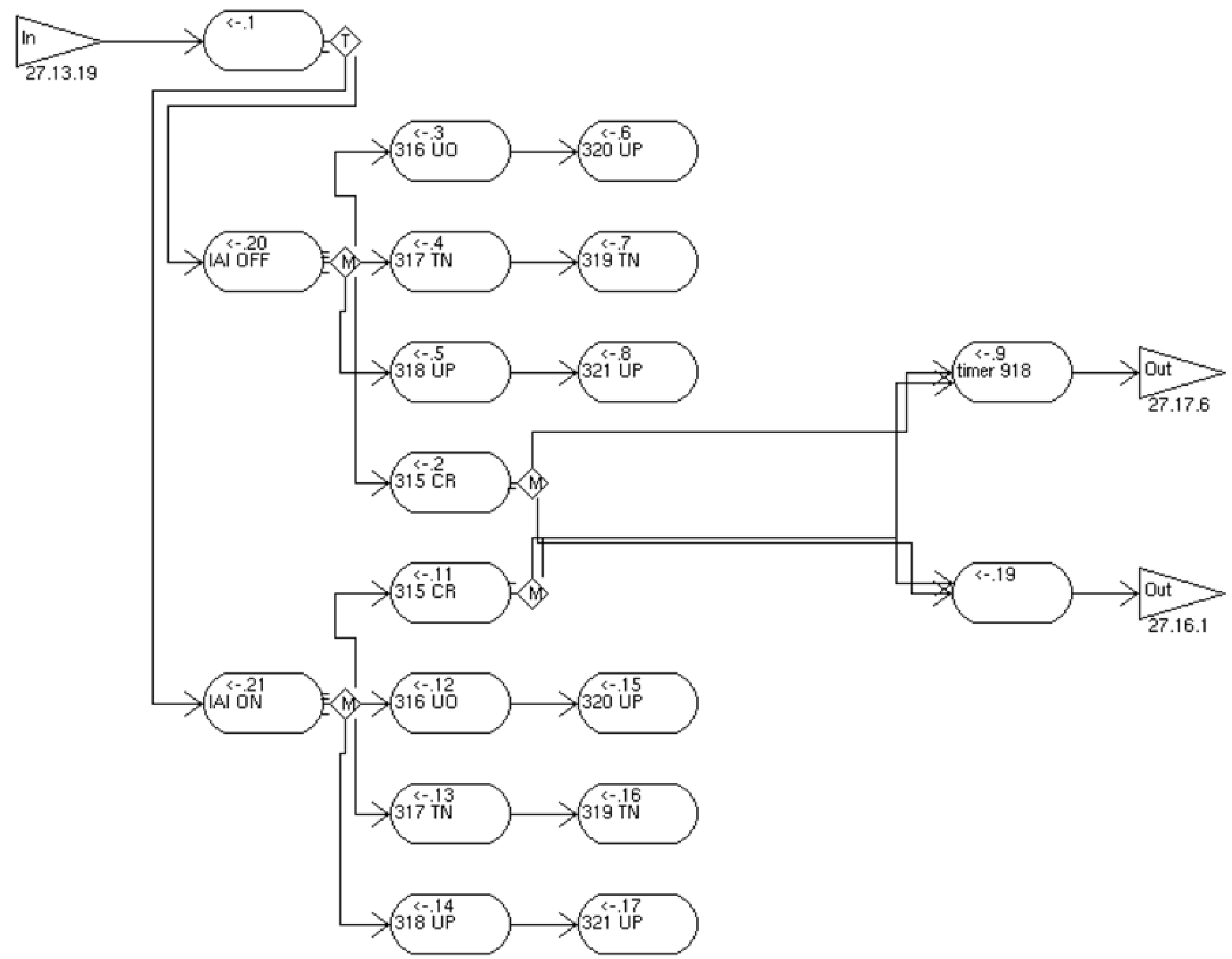


Figure F-77 Part 3 – Goal 315 ... deployment of Mini UAVs 2 To 4

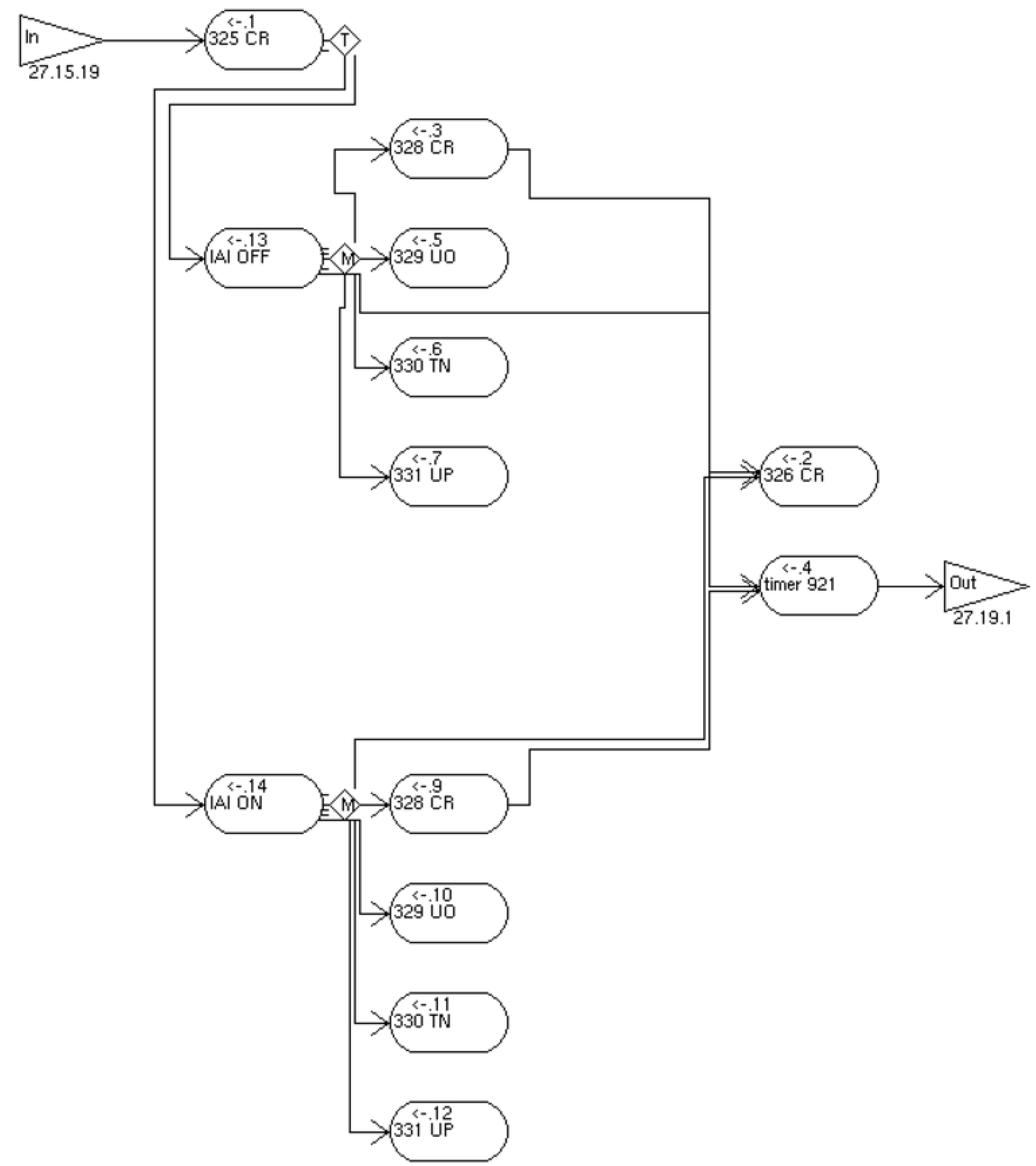


Figure F-78 Part 3 – Goal 325 ... CP140 is approaching release point for Mini UAV 5

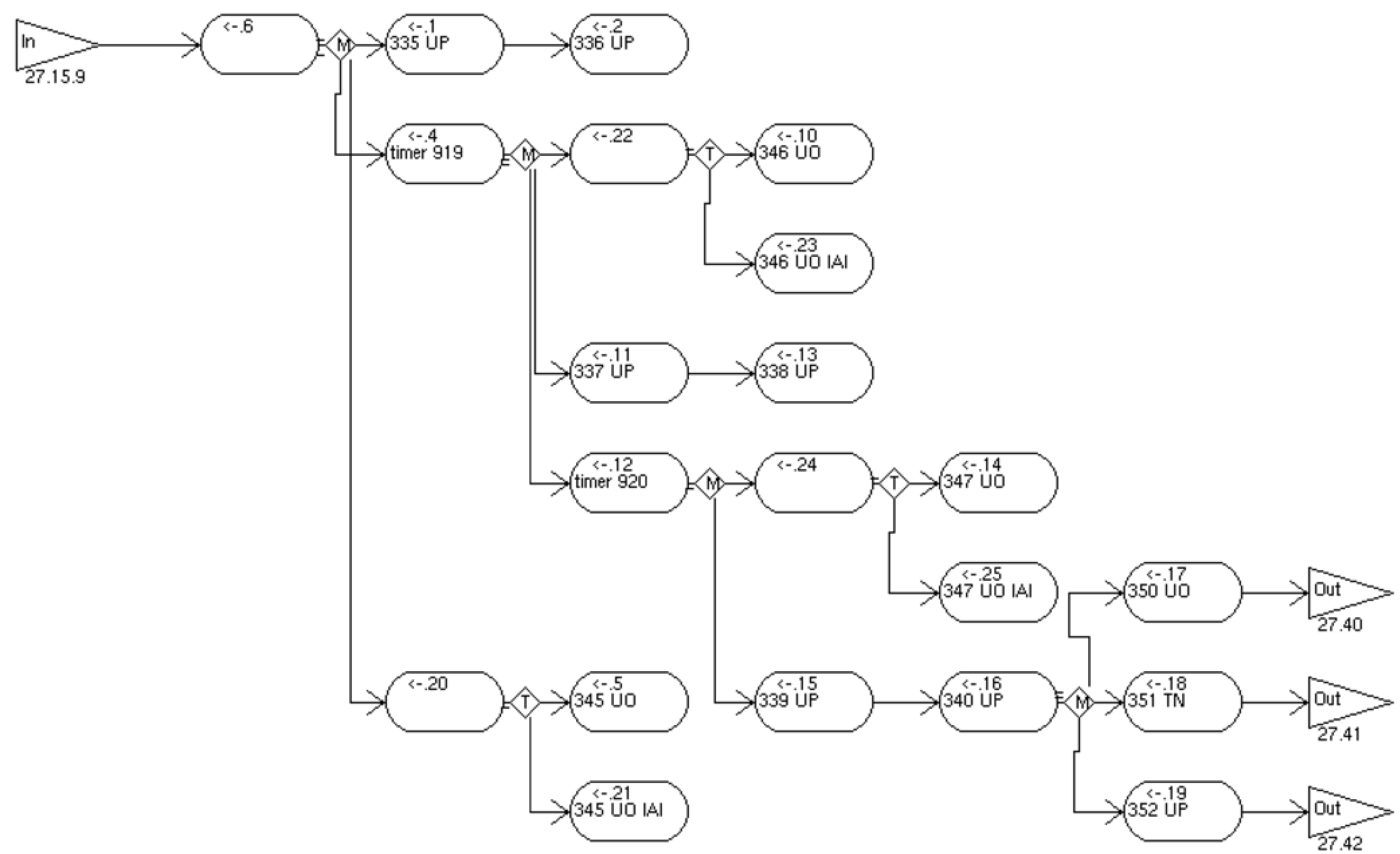


Figure F-79 Part 3 – Goal 335 ... Mini UAVs 2 to 4 are serviceable

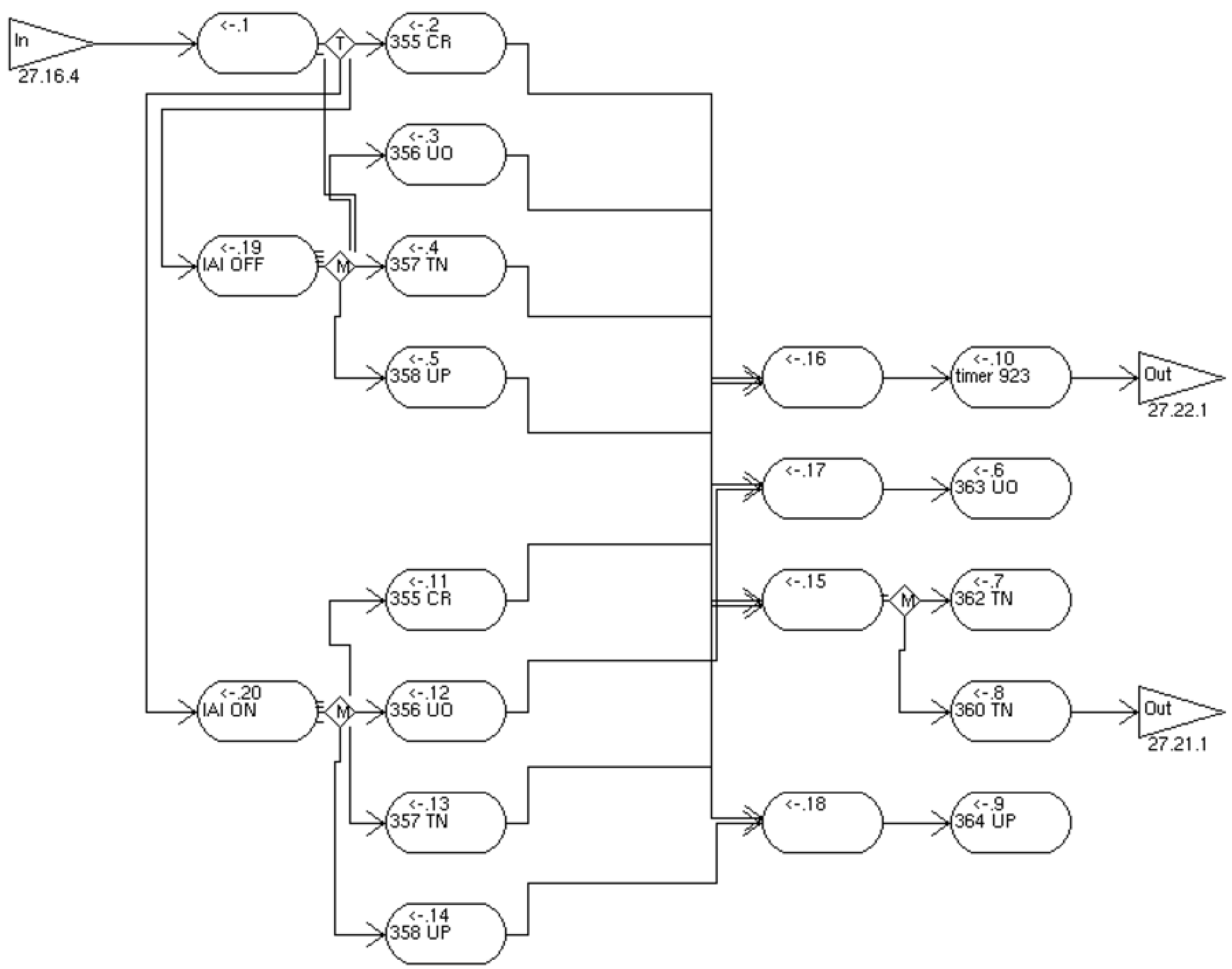


Figure F-80 Part 3 – Goal 355 ... deployment of Mini UAV 5

Figure F-81 Part 3 – Goal 366 ... CP140 is proceeding to holding waypoint

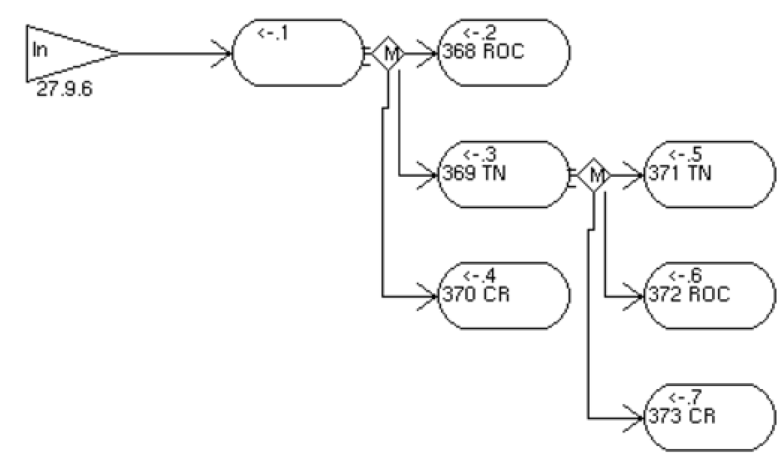


Figure F-82 Part 3 – Goal 368 ... message to direct CF188s to stand by

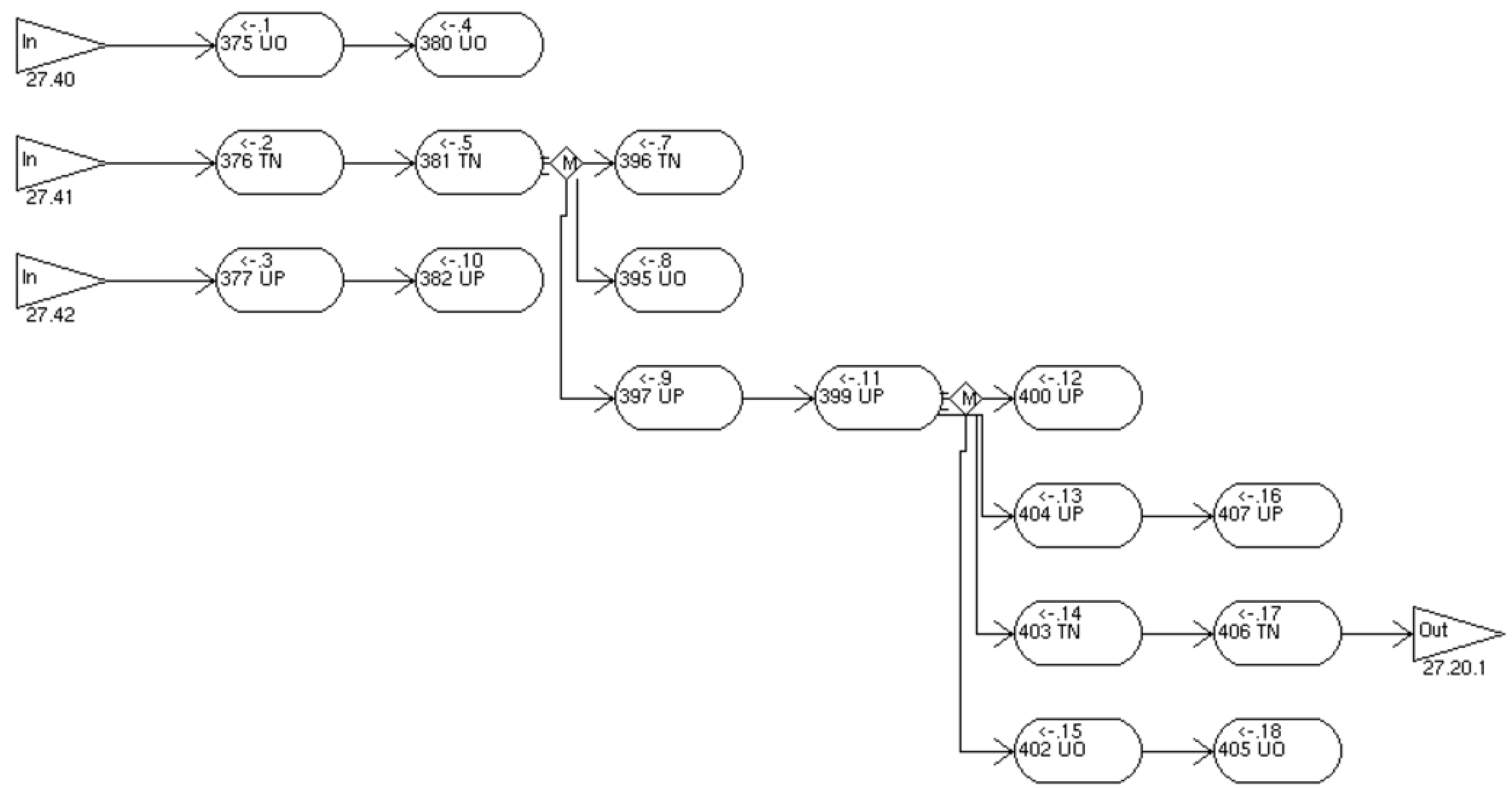


Figure F-83   Part 3 – Goal 375 ... activities on the deck of the boat that may allow classification of boat

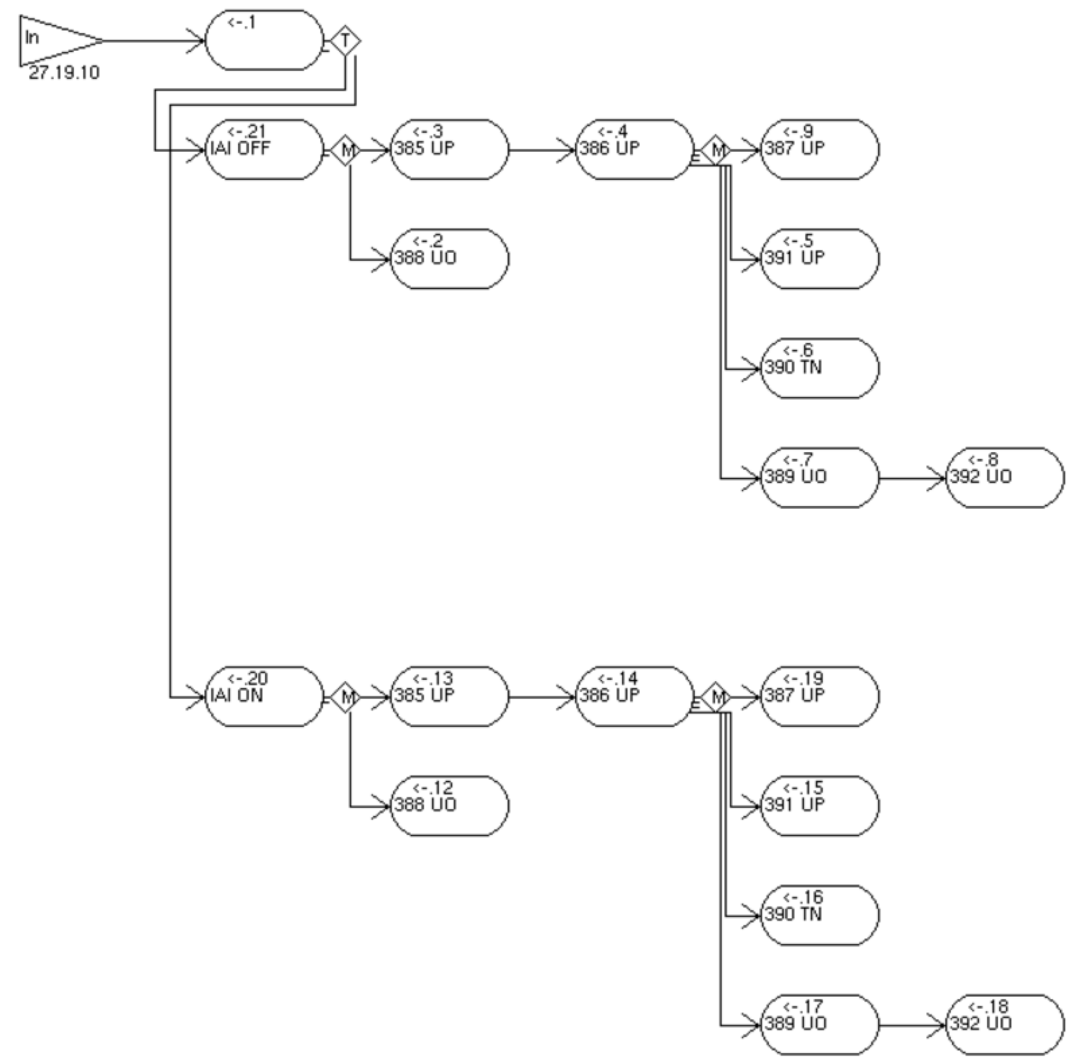


Figure F-84 Part 3 – Goal 385 ... Mini UAV 5 is employed over the downed VTUAV 1

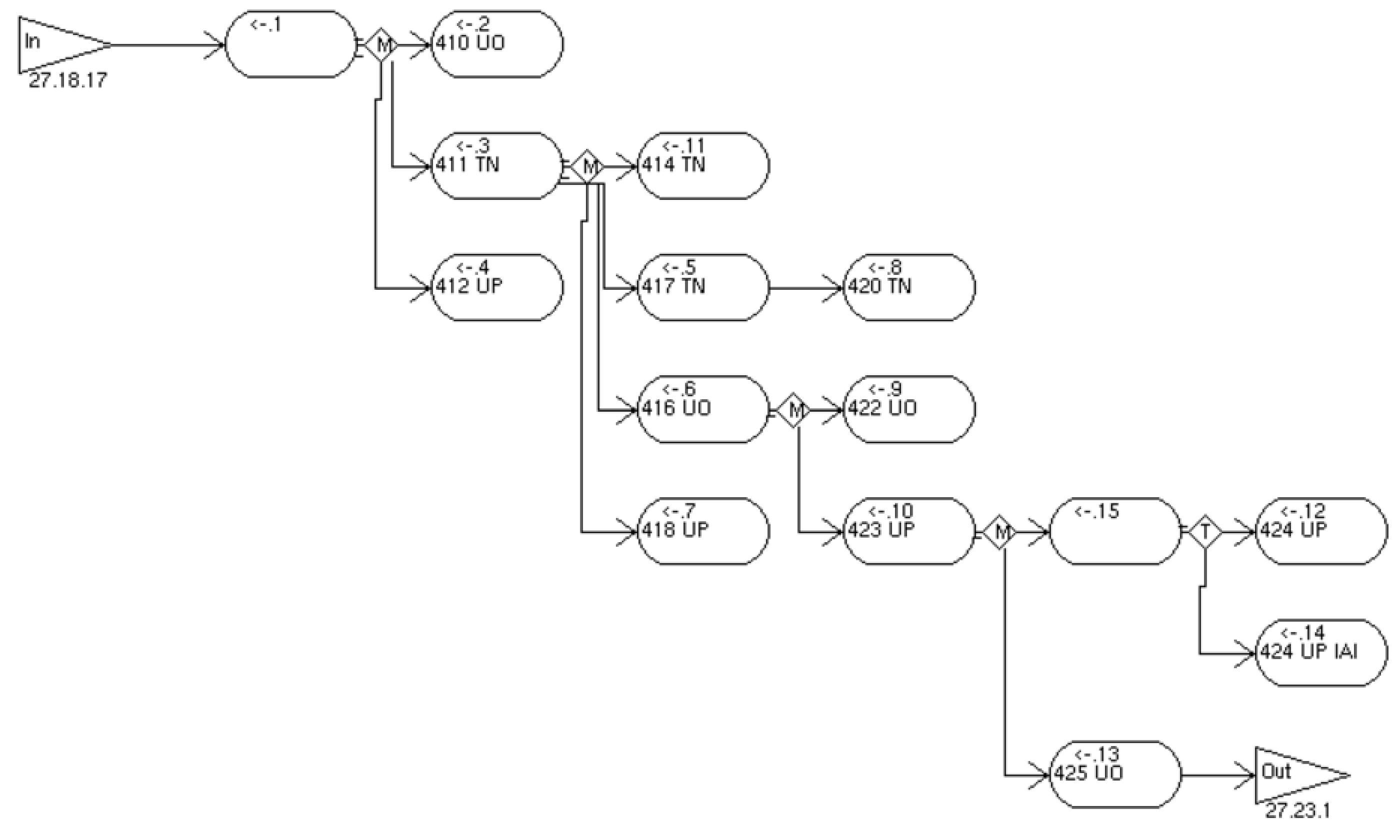


Figure F-85 Part 3 – Goal 410 ... classification of the terrorist vessel is completed

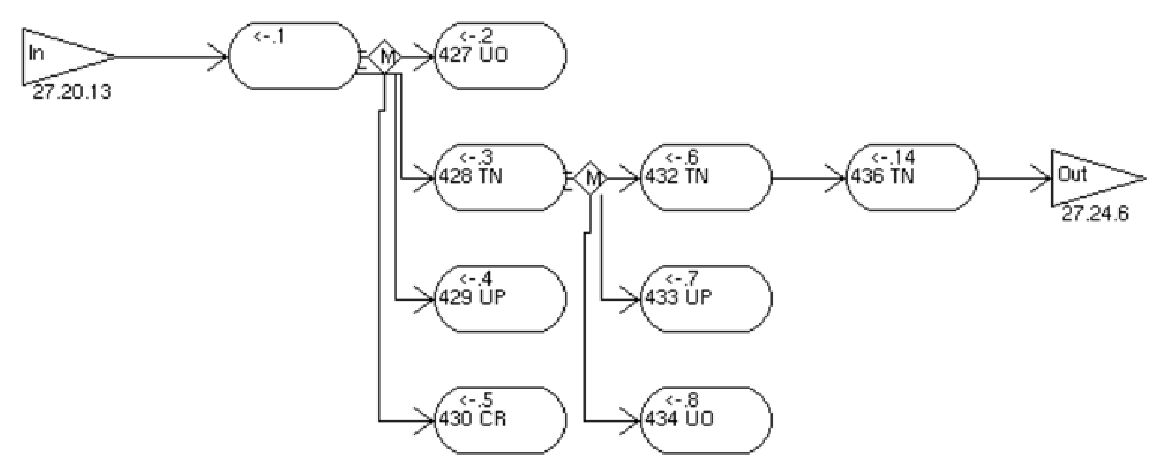


Figure F-86 Part 3 – Goal 427 ... decision to attack the terrorist boat is made

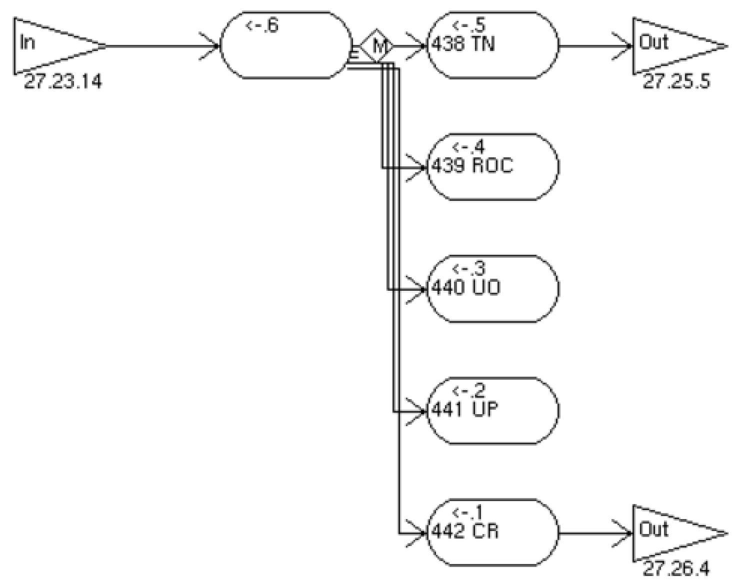


Figure F-87 Part 3 – Goal 438 ... CF188 attack has been authorized

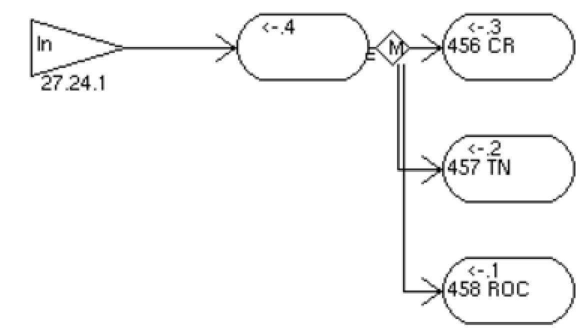


Figure F-89 Part 3 – Goal 456 ... MALE UAV will be kept clear of CF188s

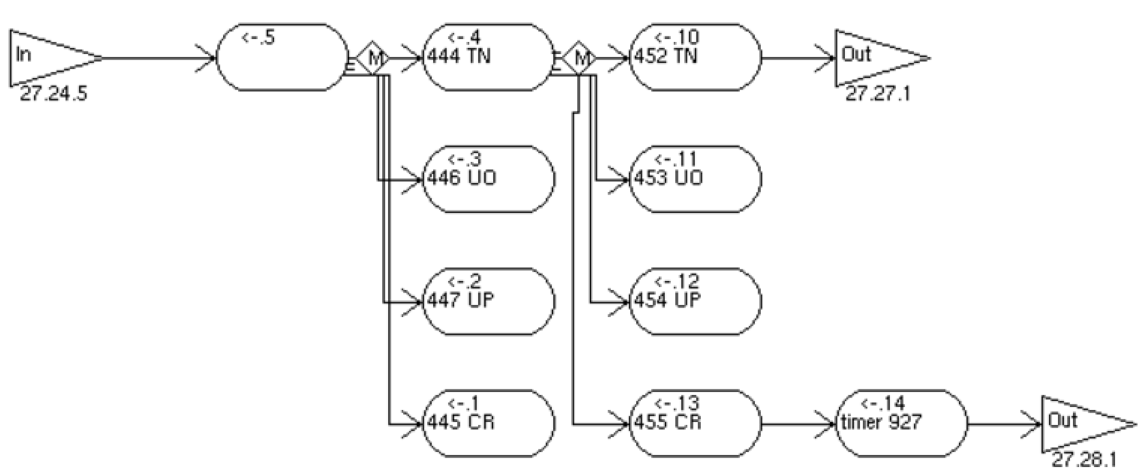


Figure F-88 Part 3 – Goal 444 ... CP140 crew have initiated activities to deploy Laser Mini UAV

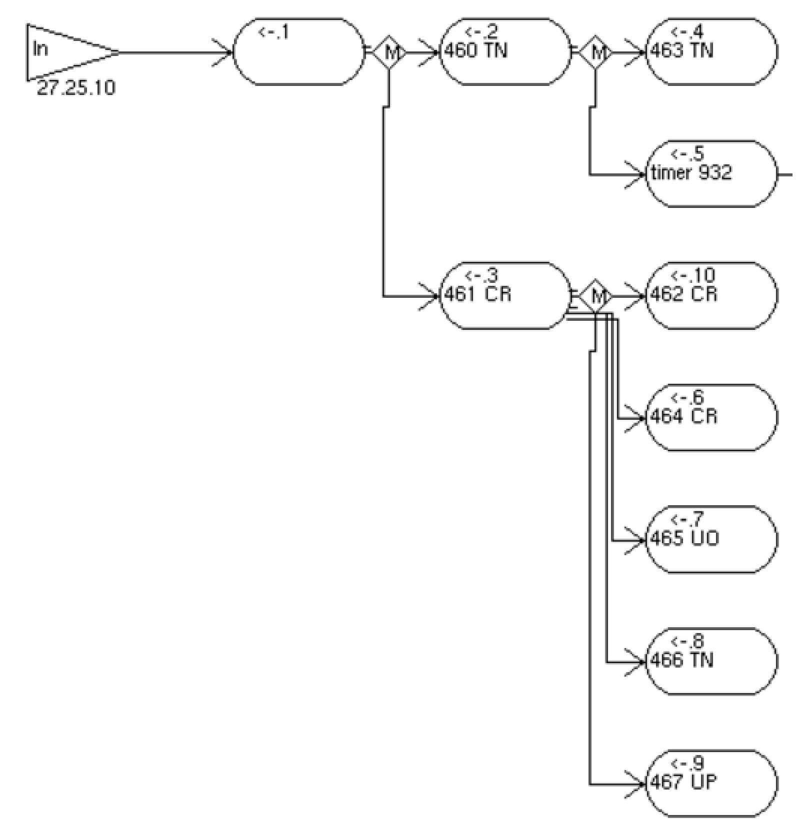


Figure F-90 Part 3 – Goal 460 ... CP140 response to possible Lethal UAV launch is planned

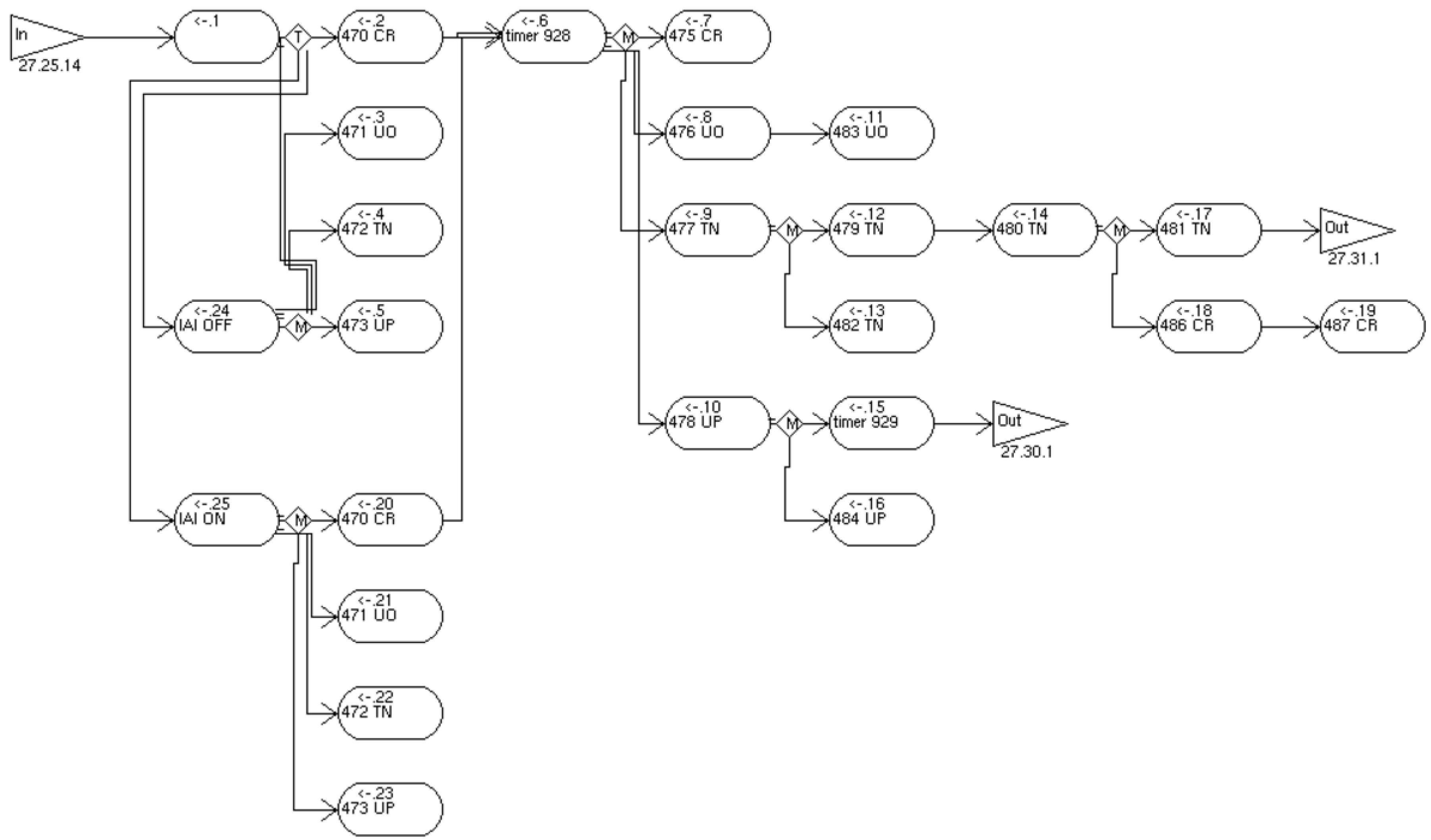


Figure F-91 Part 3 – Goal 470 ... Laser UAV is deployed from CP140 over terrorist boat

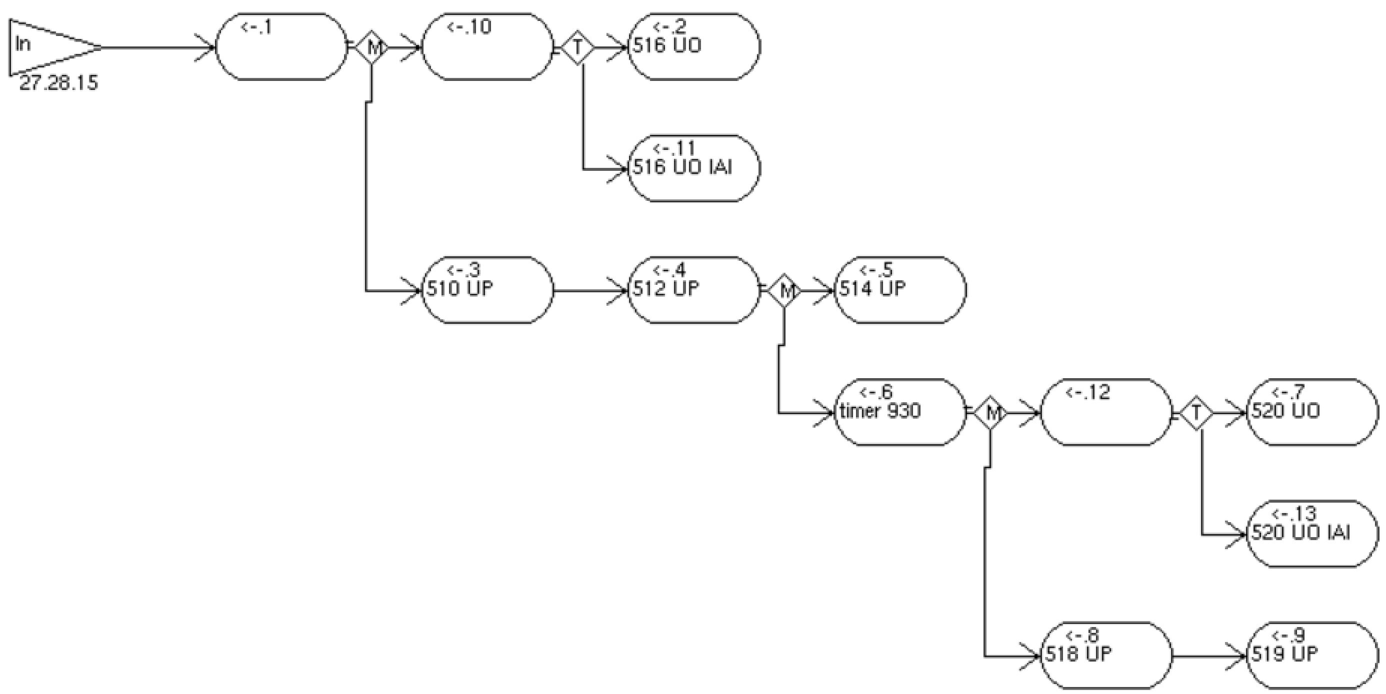


Figure F-92 Part 3 – Goal 510 ... control of the Laser UAV is established

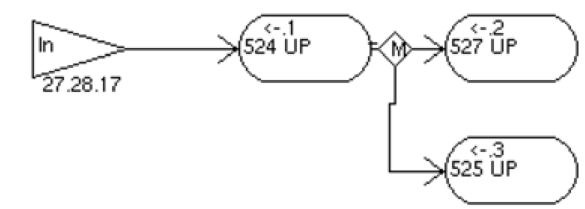


Figure F-93 Part 3 – Goal 524 ... VTUAV 2 will remain clear of CF188 attack

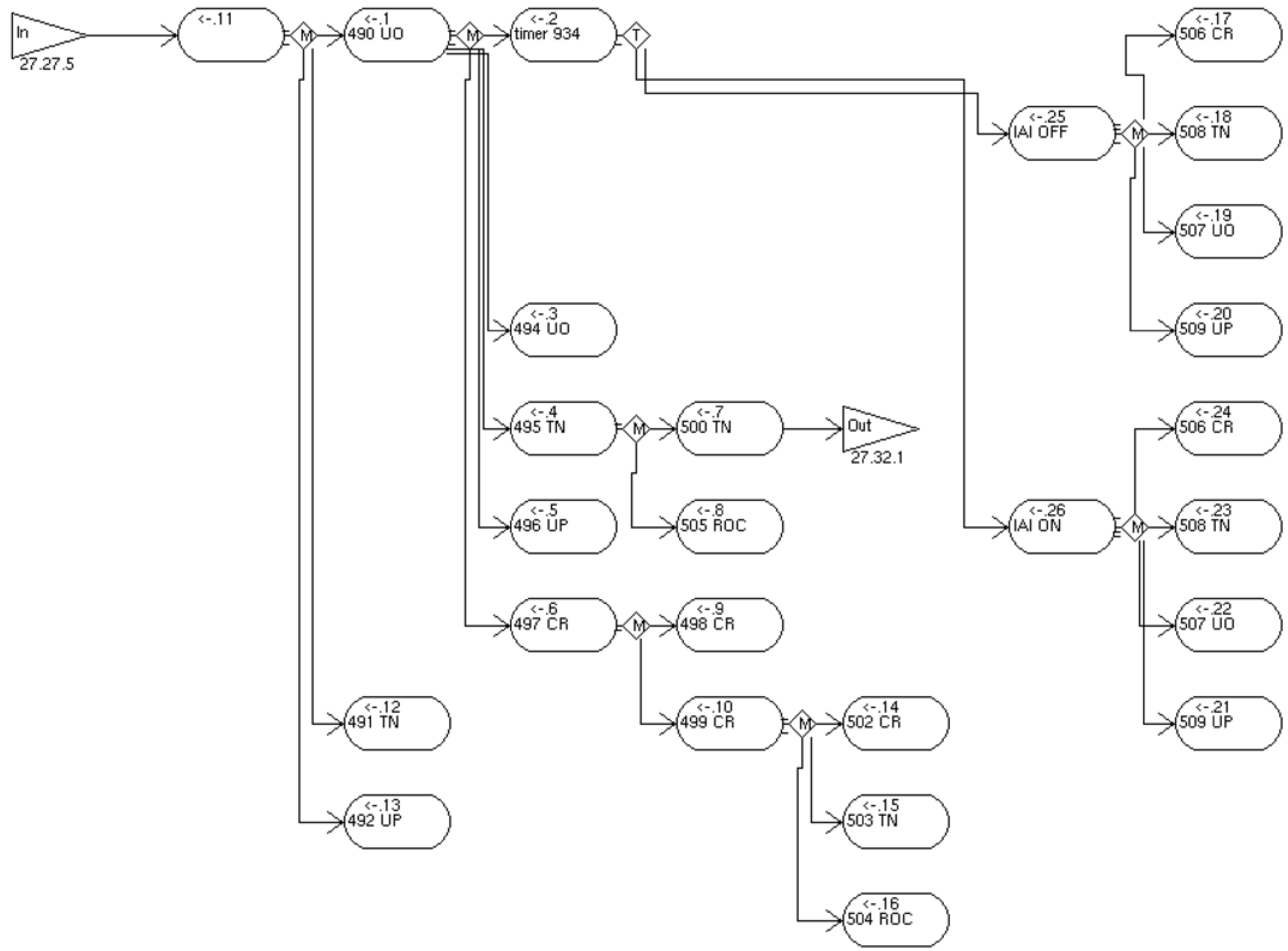


Figure F-94 Part 3 – Goal 490 ... launch of Lethal UAV noted and initial response completed

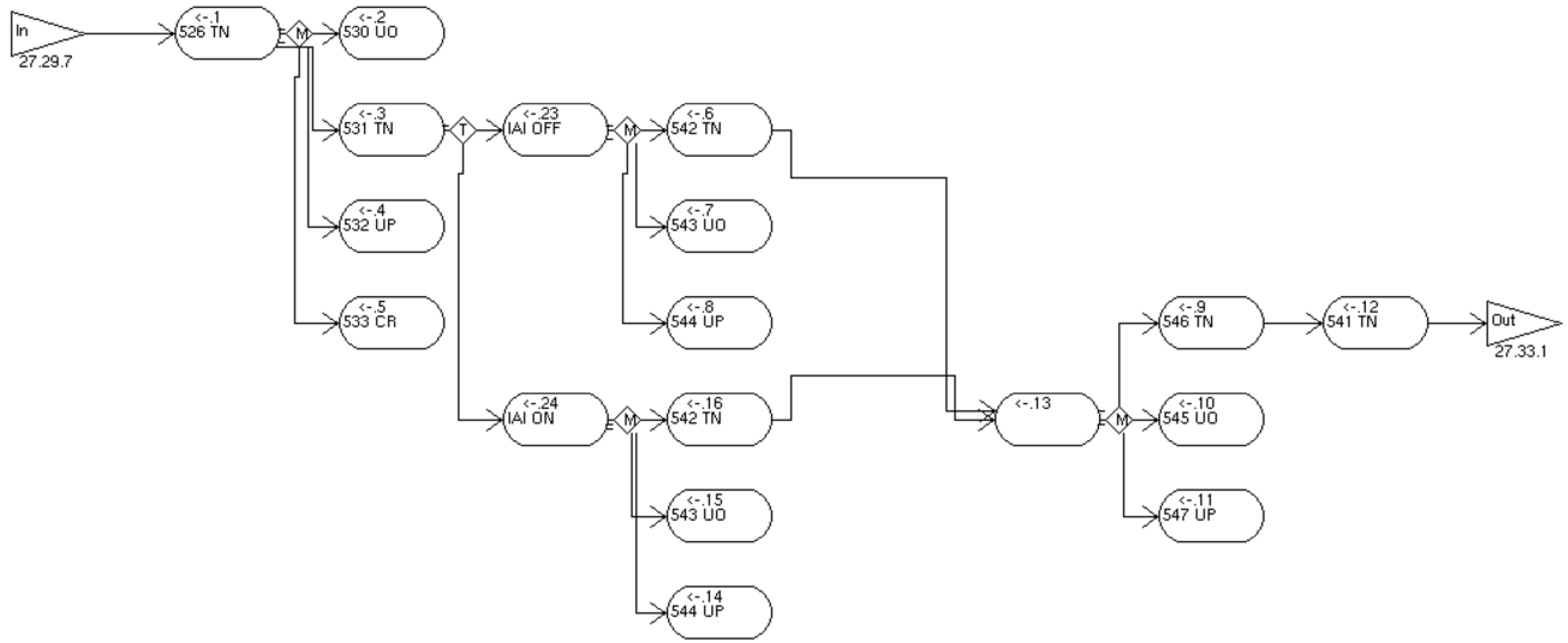


Figure F-95 Part 3 – Goal 526 ... reassessment of the need to attack terrorists is completed

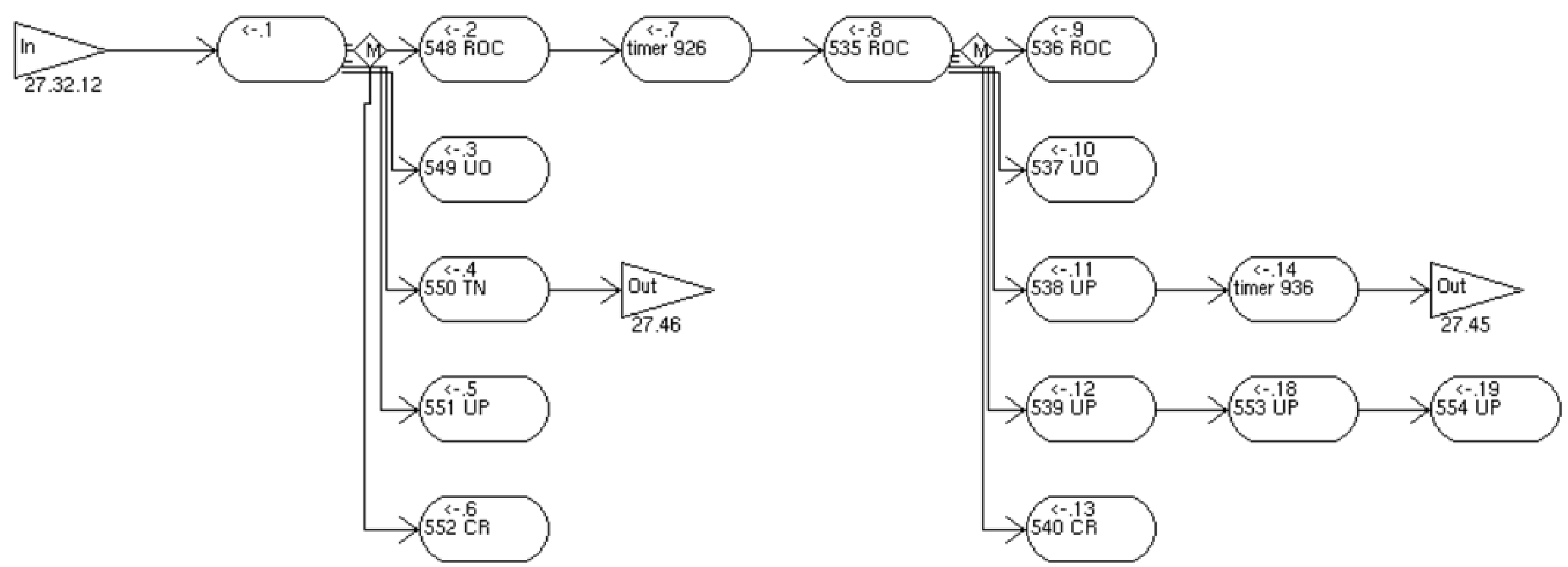


Figure F-96 Part 3 – Goal 550 ... directing, authorizing and authenticating the CF188 attack completed

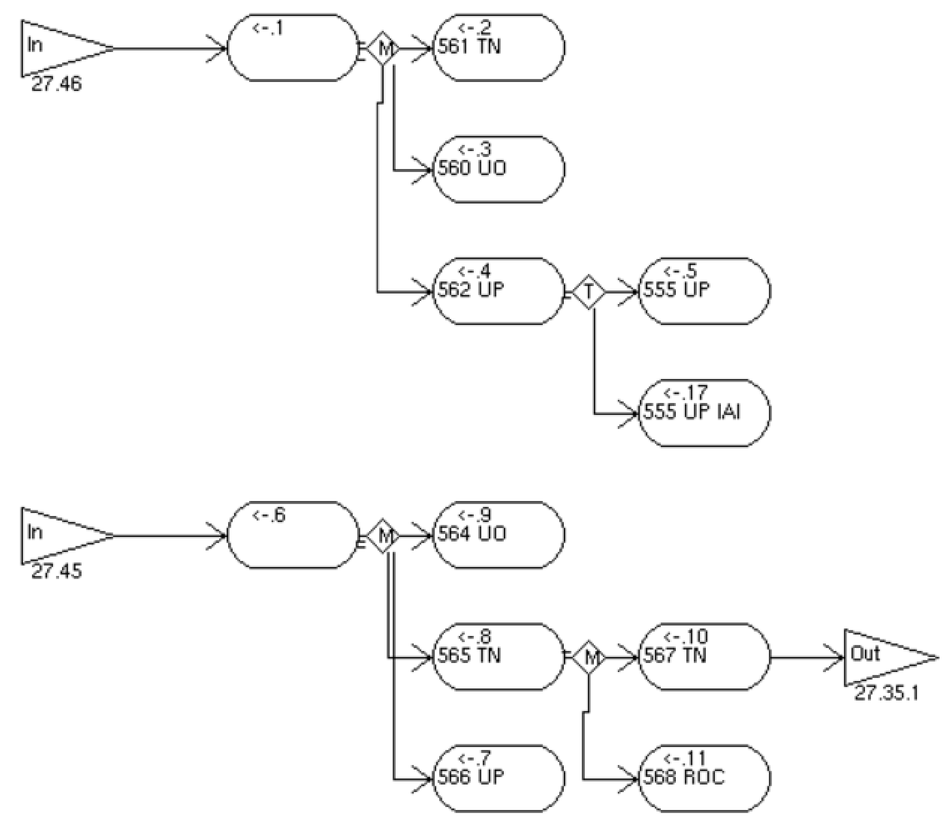


Figure F-97 Part 3 – Goal 560 ... utilization of Mini UAV during CF188 attack coordinated

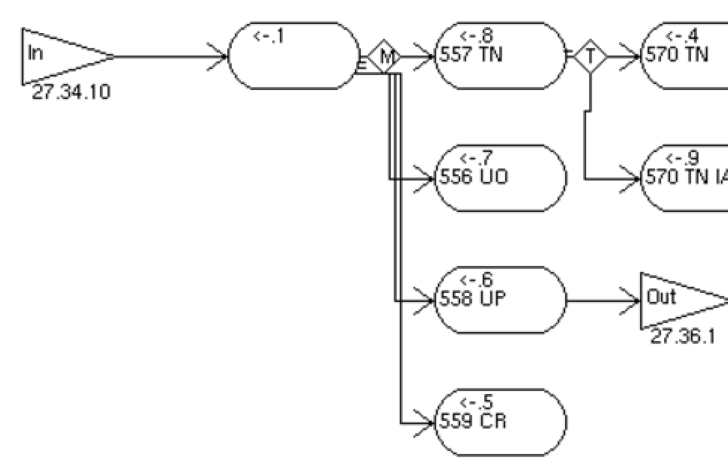


Figure F-98 Part 3 – Goal 556 ... search for Lethal UAV discussed and search plan initiated

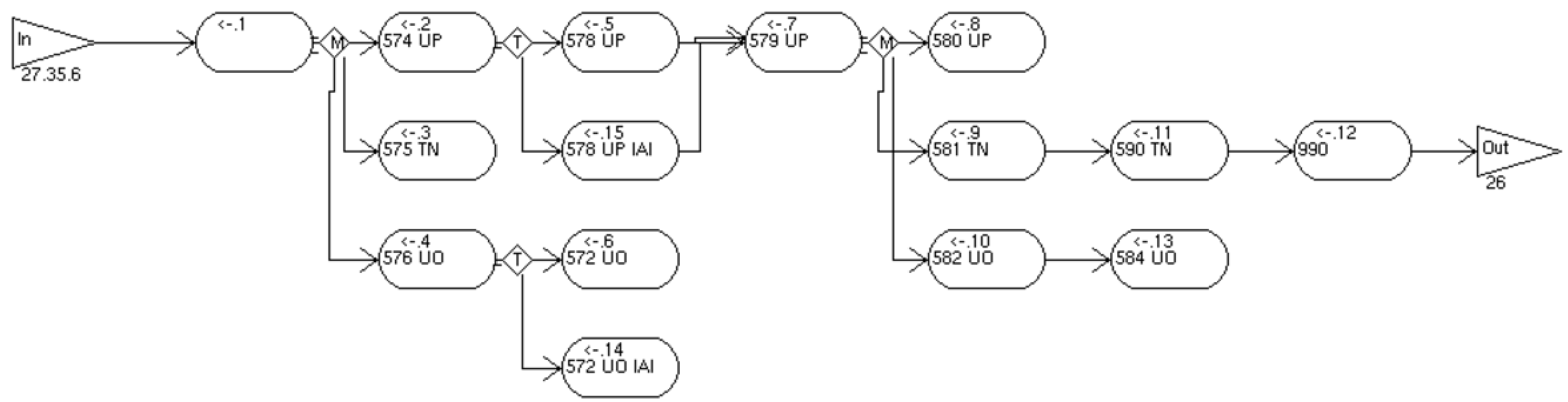


Figure F-99 Part 3 – Goal 574 ... all UAVs are set to autonomous mode to allow CP140 to commence search

ANNEX E

PERCEPTUAL CONTROL THEORY

14 June 2004

ANNEX E
PERCEPTUAL CONTROL THEORY

E.1.0 GENERAL

This Annex incorporates a detailed description of the Information Processing (**IP**)/Perceptual Control Theory (**PCT**) which is implemented in the Integrated Performance Modelling Environment (**IPME**) software used for this project. The document is a yet to be published draft produced by Mr. K. Hendy of Defence R&D Canada – Toronto and is included herein because the underlying algorithms as fundamental to the implementation of the IPME networks contained in Annex F. The Executive summary on page iii of this draft report provides an outlines the document.

Copy No: _________

An Introduction to the IP/PCT Model Implementation in IPME

Keith C. Hendy
HFRE Section, DRDC Toronto

DRAFT

Defence R&D Canada - Toronto

Technical Report

SL 2003-xxx

2004-09-14

Author

Keith C. Hendy

Approved by

Keith Hendy

Head, HFRE Section

Approved for release by

Kathy Sutton

Head, Document Review and Library Committee

Abstract

This document provides a description of the Information Processing (IP)/Perceptual Control Theory (PCT) model implemented in the Integrated Performance Modelling Environment software by Micro Analysis and Design. The current document is an edited and reduced version of an earlier report. In the current document, an attempt has been made to improve readability through a reorganisation of the material and the elimination of content that is not central to understanding the function of the IP/PCT model within IPME. The essence of the IP model is that all factors that impact on human cognitive workload can be reduced to their effects on the amount of information to be processed and the amount of time available before the decision has to be actioned. From this position, it can be shown that if humans are limited at the rate at which they process information then operator workload, performance, and error production are all functions of the time pressure. The IP Model is about time and the information to be processed.

The PCT Model argues that humans behave as multi-layered closed loop control systems. The set points for these control loops are our perceptual goals (or how we want to see, hear, feel, taste, or smell the state of the world). According to PCT, we sense the world state, forming a perception of that state which we then compare with our goal. If there is a difference between our perceived and desired states, we formulate an action. This action is implemented in order to operate on the world so as to drive the perceived state of the variables of interest towards the goal. The perceptual processes and the decisional processes draw on internal knowledge states that transform sensation to perception, and difference to action. Our attentional mechanism shifts our focus from loop to loop to loop. The PCT model is therefore about Goals, Attention, Knowledge and Feedback.

Résumé

[Enter text: French]

This page intentionally left blank.

Executive summary

The Integrated Performance Modelling Environment (IPME) is a software package for performing mission, function and task analysis (MFTA) of complex human-machine systems. Using data from the MFTA, task networks can be built from which human and system performance can be predicted. The addition of models of human information processing capability reduce the burden of the analyst in making the task networks sensitive to human capabilities and limitations. IPME is a joint development between *Qinetic* of the United Kingdom and *Defence R&D Canada*. IPME is available from Micro Analysis and Design of Boulder Colorado.

This document provides a description of the Information Processing (IP)/Perceptual Control Theory (PCT) model implemented in the IPME. The current document is an edited and reduced version of an earlier report that formed the basis of the software specification for the IP/PCT implementation. In the current document, an attempt has been made to improve readability through a reorganisation of the material and the elimination of content that is not central to understanding the function of the IP/PCT model within IPME. The essence of the IP model is that all factors that impact on human cognitive workload can be reduced to their effects on the amount of information to be processed and the amount of time available before the decision has to be actioned. From this position, it can be shown that if humans are limited at the rate at which they process information then operator workload, performance, and error production are all functions of the time pressure. The IP Model is about time and the information to be processed.

The PCT Model argues that humans behave as multi-layered closed loop control systems. The set points for these control loops are our perceptual goals (or how we want to see, hear, feel, taste, or smell the state of the world). According to PCT, we sense the world state, forming a perception of that state which we then compare with our goal. If there is a difference between our perceived and desired states, we formulate an action. This action is implemented in order to operate on the world so as to drive the perceived state of the variables of interest towards the goal. The perceptual processes and the decisional processes draw on internal knowledge states that transform sensation to perception, and difference to action. Our attentional mechanism shifts our focus from loop to loop to loop. The PCT model is therefore about Goals, Attention, Knowledge and Feedback.

Hendy, K.C. 2003. An introduction to the IP/PCT Model implementation in IPME. SL 2003-xxx. Defence R&D Canada — Toronto.

Sommaire

[Enter text: French]

[Enter surname, initials for all authors]. [Enter year]. [Enter title]. [Enter report no.]
[Enter research centre name].

Table of contents

List of figures

List of tables

This page intentionally left blank.

Introduction

This document provides a description of the Information Processing (IP)/Perceptual Control Theory (PCT) model implemented in the Integrated Performance Modelling Environment (IPME; see http://www.maad.com/MaadWeb/products/ipme/ipmema.htm). The current document is an edited and reduced version of an earlier report (Hendy, 1994a) which formed the specification for the software development. In the current document, an attempt has been made to improve readability through a reorganisation of the material and the elimination of content that is not central to understanding the function of the IP/PCT model within IPME.

The IP Model is described in detail elsewhere (Hendy, East, and Farrell, 2001b; Hendy, Liao, and Milgram, 1997). The essence of the IP model is that all factors that impact on human cognitive workload can be reduced to their effects on the amount of information to be processed and the amount of time available before the decision has to be actioned. From this position, it can be shown that if humans are limited at the rate at which they process information then operator workload, performance, and error production are all functions of the time pressure. Time Pressure is proportional to:

$$\mathit{Time\ Pressure} \propto \frac{\mathit{Amount\ of\ information\ to\ be\ processed}}{\mathit{Time\ available}}$$

which, at a constant rate of processing, reduces to,

$$\mathit{Time\ Pressure} = \frac{\mathit{Time\ to\ process\ information}}{\mathit{Time\ available}}.$$

The IP Model is about time and the information to be processed (knowledge). The IP model applies everywhere in the human cognitive system where information is being processed.

A fundamental assumption of the IP model is that information is processed serially within a given structure. Interference in multiple concurrent task performance is assumed to depend on the amount of physical overlap between the structures involved in processing each task. It is expected that task interference, assuming a constant strategy, will manifest itself as an increase in the processing or decision time for one or more of the tasks (Hawkins, Olbrich-Rodriguez, Halloran, *et al*., 1979). This is a direct consequence of the competition for serial resources. Note that the concept of *overlap* is assumed to exist at the neural level. This view is consistent with the architecture described by Detweiler and Schneider (1991) for a connectionist model of skill acquisition.

In the IP model, the selection of a specific information processing strategy is assumed to involve a specific set of processing structures. Different strategies will, in general, involve different structures. The selected strategy also characterises the *depth of processing* and sets the total amount of information to be processed, and hence the time in arriving at a decision. Time and the amount of information to be processed are always related linearly by the fixed processing rate.

The PCT Model (Powers, 1973) argues that humans behave as multi-layered closed loop control systems (See Figure 1). The set points for these control loops are our perceptual goals (or how we want to see, hear, feel, taste, or smell the state of the world). According to PCT, we sense the world state, forming a perception of that state which we then compare with our goal (as shown by the ∑ sign in Figure 1 which represents the mathematical summing operation). If there is a difference between our perceived and desired states, we formulate an action. This action is implemented in order to operate on the world so as to drive the perceived state of the variables of interest towards the goal. The perceptual processes and the decisional processes draw on internal knowledge states that transform sensation to perception, and difference to action. Our attentional mechanism shifts our focus from loop to loop to loop. The PCT model is therefore about Goals, Attention, Knowledge and Feedback.

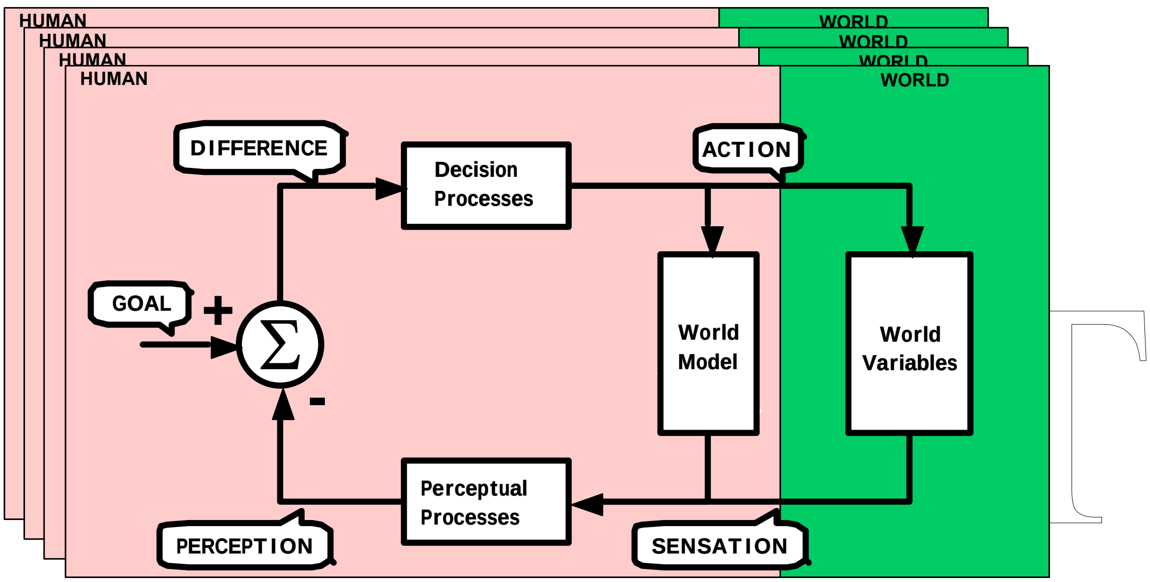


***Figure 1.** The multi-layered Perceptual Control loop for a human operator interacting with the world.*

The IP model acts wherever there are data transformation or information processing actions. These occur in the perceptual processes, the decisional processes and in the internal world model processes. Combining the IP and PCT models it is shown that human decision-making depends on the management of time, knowledge and attentional resources (Hendy and Lichacz, 1999). The IP and PCT models are complementary. The dynamic behaviour of the PCT model is bandwidth limited with this limitation coming from the lags and delays in the terms of the transfer functions (Decision and Perceptual Processes). The IP model provides a mechanism for explaining these delays and shows how strategy selection provides a trade-off between speed of response and absolute accuracy of performance. By going to a less accurate, less computationally intensive strategy, transport delays will be less and the dynamic response will increase due to the increased bandwidth. Transport delays are a product of the time required to process the information (bits) associated with selecting and forming an action at a finite processing rate (bits s^{-1}).

Multiple Task Performance

In the IP/PCT model, elements of multiple concurrent tasks that draw on the same processing structures are assumed to be processed serially by time-multiplexing. The first assumption to be made, and perhaps the most fundamental, is that operators will service no more than 2 tasks concurrently for which the degree of interference is non-zero (Hendy, 1994b). While the literature on dual task (e.g., Wickens, 1992, p. 364ff.) performance is abundant, information on multiple (more than 2) task performance is less prodigious. While the restriction to dual tasking probably provides a conservative prediction, overt multiple task performances appear to be rare in operational systems (Shaffer, Hendy, and White, 1988). The restriction to dual tasking will be limited to tasks that require higher level processing, say at the level of Rasmussen's rule-based and knowledge-based activities (Rasmussen, 1983). There is no limit set on the number of purely skill-based activities (these are designated Category 1 in Table 3, see p. 10) that can be performed in concert, provided there are no structural interference limitations (see discussion on p. 7).

Time-multiplexing

Suppose that the performance of tasks *i* and *j* overlap in the time domain. Then it is assumed that processing two tasks that share a common structure will occur by rapidly time-multiplexing within that structure as illustrated in Figure 2 (zero switching time is assumed). In Figure 2, Tasks 1 and 2 are shown to be processed on successive processing intervals (assuming equal priority is given to both tasks). The reaction times of both tasks will be delayed by this form of processing. Note that:

T_i is the task completion time of the *i*th task when performed in isolation, and

T_{ij} is the task completion time of the *i*th task when performed in combination with the *j*th task.

Suppose that, instead of successively switching from one task to the other, there is a probability associated with the allocation of a processing structure to each task within a given interval (Kinchla, 1980). Assume that in any processing interval, the probability that the processing structure is assigned to the *i*th task is p_i. Then on average, over any given time period, a proportion p_i of the processing time is devoted to task *i*, while a proportion $p_j = (1-p_i)$ is devoted to task *j*.

In general, suppose tasks *i* and *j* do not require the same processing structures for all of their processing time, but share a common structure for a proportion (as defined by the coefficient $\mathbf{c}_{ij}$) of the period of their overlap in the time domain. Two cases need to be considered:

CASE 1 — in which the processing of one of the tasks (assume it to be task *j*) is entirely embedded within the processing time of the other (task *i*); and

CASE 2 — in which the tasks partially overlap (the processing time of task *i*, remaining after task *j* starts, is entirely embedded within the processing time of task *j*).

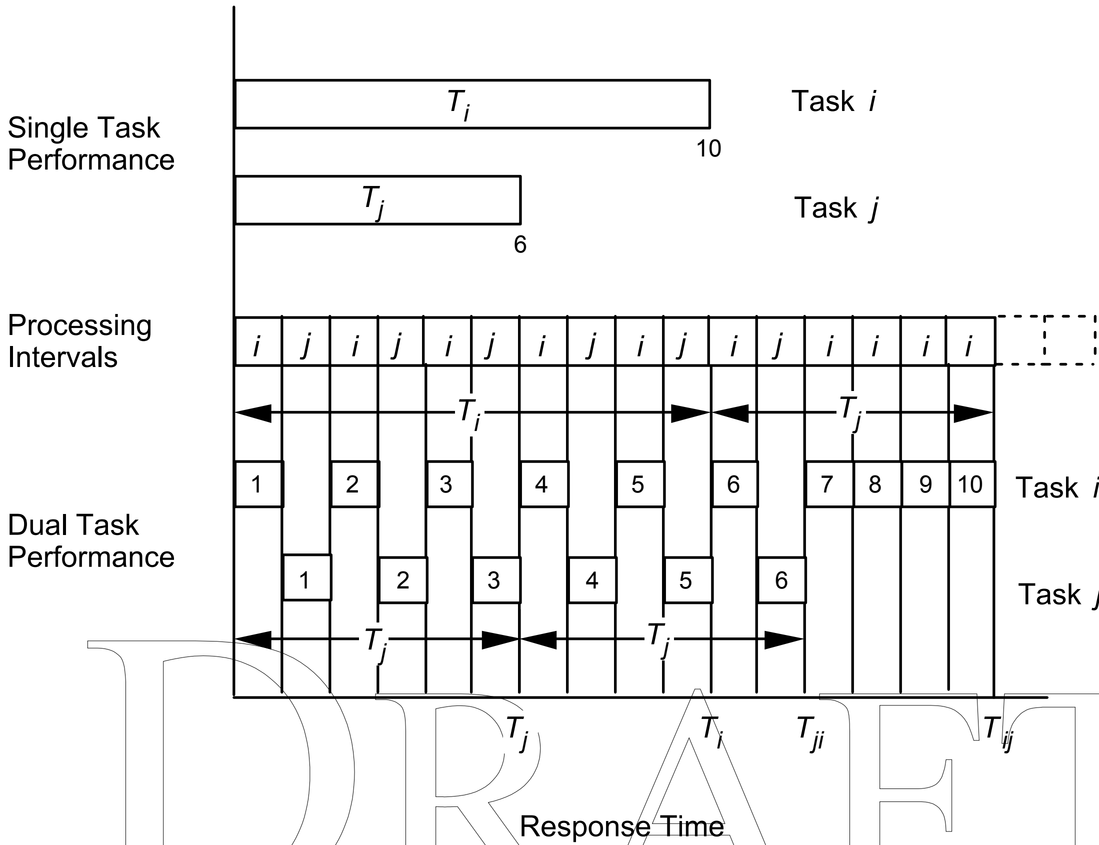


Figure 2. **An example of time-multiplexing in 'concurrent' task processing (CASE 1 - two tasks completely overlapping)**

Let

$t_i(\mathrm{s})$ be the starting time of the *i*th task, and

$t_{ij}(\mathrm{e})$ be the ending time of the *i*th task when performed in combination with the *j*th task.

$t_{ij}(\mathrm{e})$ $t_i(\mathrm{s})$ be the start time of task *i*,

$t_i(\mathrm{e})$ be the ending time of task *i*, when performed alone,

$t_{ij}(\mathrm{e})$ be the ending time of task *i*, when performed with task *j*,

δT be the processing time overlap between the *i*th and *j*th task,

$\mathbf{c}_{ij}$ be the proportion of time (δT) that the overlapping tasks share a common processing structure (for simplification, this time is assumed to be evenly distributed throughout the overlap), and

p_i be the probability that in any given time interval, processing resources will be devoted to task *i*, rather than task *j* (note that $p_i = (1 - p_j)$).

Then for CASE 1, $\left[t_j(\mathsf{s})-t_i(\mathsf{s})\right]\geq 0$ and $t_{ij}(\mathsf{e})\geq t_{ji}(\mathsf{e})$, and assuming that the requirement to share common structures is distributed evenly throughout the period of overlap, it can be shown that

$$T_{ij} = T_i + \frac{\mathbf{c}_{ij}\left(1-p_i\right)}{1-p_i\mathbf{c}_{ij}}T_j, \tag{4a}$$

$$T_{ji} = \frac{T_j}{1-p_i\mathbf{c}_{ij}}, \text{ and} \tag{4b}$$

$$T_i - T_j\left[\frac{1-\mathbf{c}_{ij}\left(1-p_i\right)}{1-p_i\mathbf{c}_{ij}}\right] - \left\{t_j(\mathsf{s})-t_i(\mathsf{s})\right\}\geq 0. \tag{4c}$$

Similarly, for CASE 2, $\left[t_j(\mathsf{s})-t_i(\mathsf{s})\right]\geq 0$ and $t_{ij}(\mathsf{e}) < t_{ji}(\mathsf{e})$, and

$$T_{ij} = \frac{\left[T_i - p_j\mathbf{c}_{ij}\left\{t_j(\mathsf{s})-t_i(\mathsf{s})\right\}\right]}{1-p_j\mathbf{c}_{ij}}, \tag{5a}$$

$$T_{ji} = \frac{\left(1-p_j\mathbf{c}_{ij}\right)T_j + \mathbf{c}_{ij}\left(1-p_j\right)T_i - \mathbf{c}_{ij}\left(1-p_j\right)\left\{t_j(\mathsf{s})-t_i(\mathsf{s})\right\}}{1-p_j\mathbf{c}_{ij}}, \text{ and} \tag{5b}$$

$$T_i - T_j\left[\frac{1-\mathbf{c}_{ij}\left(1-p_i\right)}{1-p_i\mathbf{c}_{ij}}\right] - \left\{t_j(\mathsf{s})-t_i(\mathsf{s})\right\} < 0. \tag{5c}$$

In these two sets of expressions, the inequality classifies the situation according to case.

If the proportion of the time devoted to processing each task is determined by task priorities P_i and P_j, then

$$p_i = \frac{P_i}{P_i + P_j}. \tag{6}$$

The task priority values (P_i and P_j) are determined by the instantaneous time pressures for the tasks (see p. 21).

To allow for task resumption after an interruption it is necessary to keep a running total of the amount of actual processing time devoted to each task and conversely the amount of processing time remaining for each task. At any time $t_j(\mathsf{s})\leq t \leq t_{ji}(\mathsf{e})$, the amount of processing time devoted to resumable task *i*, since task *j* commenced, is

$$\Delta T_{ij} = p_i\mathbf{c}_{ij}\left\{t - t_j(\mathsf{s})\right\} + \left(1-\mathbf{c}_{ij}\right)\left\{t - t_j(\mathsf{s})\right\} \tag{7}$$

and to task *j*

$$\Delta T_{ji} = \left(1-p_i\right)\mathbf{c}_{ij}\left\{t - t_j(\mathsf{s})\right\} + \left(1-\mathbf{c}_{ij}\right)\left\{t - t_j(\mathsf{s})\right\} \tag{8}$$

Davis (1971) suggests that the time remaining on an interrupted task should be increased by some factor on resumption, and that the priority of the task should also be increased to avoid constant interruption. This might be considered to constitute a start up penalty. In Davis's model, this factor is chosen from one of four values depending on the percentage of the original task completion time remaining. For the implementation of the IP/PCT model the penalty factor is a global variable, with the possibility of modification at the task level. It takes the default value of $\mu = 1.05$ (assigned arbitrarily).

Conceptually this penalty factor represents additional information processing, due to task resumption, which must be discharged before the information remaining on the original task can be processed. The calculation of the running total will take this into account. Therefore, each time a task is interrupted two calculations are made.

1 The **actual processing time remaining** on the task $\Delta T_{act}(n)$ at the *n*th interruption. This is equal to the actual task completion time remaining when the task last started or resumed $\Delta T_{act}(n-1)$, minus the amount of processing time logged against the primary task in the current iteration, that is

if $\left(\Delta T_{ij}(n) - (\mu - 1)\Delta T_{act}(n-1)\right) > 0$ then

$$\Delta T_{act}(n) = \left(\Delta T_{act}(n-1) - \left(\Delta T_{ij}(n) - \mu\Delta T_{act}(n-1)\right)\right) \tag{9a}$$

else

$$\Delta T_{act}(n) = \Delta T_{act}(n-1) . \tag{9b}$$

Note that when $n = 1$,

$$\Delta T_{act}(1) = T_i - \Delta T_{ij}(1) .$$

2 The **effective time remaining on the task** which includes the penalty due to resumption, is

$$\Delta T_{eff}(n) = \mu\Delta T_{act}(n) \tag{10}$$

Task Interference

For multiple concurrent task performance, it is assumed that two types of interference can occur, namely, *structural* interference and *resource limited* interference. The term *structural* interference is used, quite specifically in this context, to describe interference effects that are due to limitations such as:

- the inability to focus foveally at different images, widely separated in visual angle, concurrently;
- those problems associated with operating separated controls with the same hand or limb; and
- the inability to speak two messages at the same time.

Structural limitations, in this context, have little or nothing to do with the **processing structures** involved — at least at the higher levels of processing. They are driven by physical rather than information processing limitations and are therefore assumed to be largely associated with input and output stages, rather than cognition.

Structural interference is assumed to be *all or nothing*, that is $\mathbf{c}_{ij} = 1$ or 0. Matrices of interference coefficients for the *visual*, *auditory*, *cognitive*, and *manual*/*kinesthetic* domains are shown in Tables 1, 2, 3 and 4 respectively. Default values are shown for completeness. Note that these assignments have been made somewhat arbitrarily and no claims are made for their validity.

Visual domain

The visual domain consists of a single channel for information flow. Tasks are categorised according to whether they require foveal (central) vision or can be processed peripherally (see Table 1). A home area is defined for vision, which is assumed to be the resting position of the eyes in the absence of specific **operator initiated or goal directed** eye movements. At the completion of each task that involves a visual component, or when the task is interrupted or shed, the direction of gaze is returned to this point.

It is assumed that the highest priority visual task is foveated. If, and only if, this is a task that can be performed with peripheral vision, the direction of gaze shifts to the next highest priority central visual task that satisfies the criterion for selection into the active task list (see discussion on the allocation of attention module, p. 15ff.). Hence, the direction of gaze is always either the home position or the currently selected, highest priority, visual task (with central tasks taking precedence over peripheral). To accommodate different visual environments (e.g., the use of night vision aids), one can edit the fields containing the visual subtense ranges in Table 1. Note that as some operators might be using night vision aids and other will not, these tables are set at the level of the operator. The default is that Table 1 is identical for all operators.

Table 1. Task interference coefficients (c_{ij}) for a human information processing model — visual domain.

Channel	*Mode*	*Interference*
Vision	Input	Structural ($\mathbf{c}_{ij}$ = 1 or 0)

OPERATOR INITIATED CATEGORIES	ANGULAR SUBTENSE† (DEGREES) Ø≤ 2	2<Ø≤30	30<Ø≤90	90<Ø≤180
0. None (no visual component)	**0.0**	If a task has no visual component it will not interfere with **any** visual task in this domain.		
1. Central-Central	**0.0**	**1.0**	**1.0**	**1.0**
2. Central-Peripheral	**0.0**	**0.0**	**1.0**	**1.0**
3. Peripheral-Peripheral	**0.0**	**0.0**	**0.0**	**1.0**
4. No allocation (default) with any visual task	**1.0**	As these tasks are neither allocated as central or peripheral, they will be assumed to interfere with **all** other visual tasks.		

† *These values are for* ***operator initiated*** *eye movements. Note that an externally initiated visual signal, occurring outside a certain angle (say 30°) of visual arc, will not be detected — or will be detected with a certain probability (see Table 7) — and therefore may not be 'serviced' even serially. Tasks not allocated are not serviced.*

For simplicity, each visual task is assigned to an area in the visual scene (*Area* 1, *Area* 2, etc.). A global lookup table sets the approximate (or exact) angular subtense between all pairwise combinations of these areas. These angles are used in the assessment of visual interference coefficients and probabilities of detection for externally cued stimuli. By default, *Home* is *Area* 1, although this is within the analyst's capability to change. The actual number of visual areas is set by the analyst.

Obviously, to obtain the degree of discrimination implied by Table 1, the visual scene would have to be divided up into increments of 2° of solid angle. A coarser analysis might simply assign 0° angular subtense to all tasks that share a common area. Note that the visual scene does not have to be divided evenly. A fine grid can be used in areas where there are multiple central tasks, while a coarse grid can be used elsewhere.

Auditory domain

The auditory domain consists of two channels, namely audition and vocalisation. Five types of auditory and vocal signals are considered. They are:

- tones or simple auditory cues such as buzzers, bells, chimes and horns,
- speech that is incidental to the current activities — monitored for presence and general content rather than for detailed meaning
- complex auditory signals and patterns (e.g., sonar signals, Morse code)
- attended speech (i.e., speech that is directly relevant to current activities), and
- voice output.

Table 2 lists the interference coefficients for this domain. Note that interference is assumed to be structural ($\mathbf{c}_{ij}$ = 1 or 0). As a starting point, and subject to validation, few interference effects are postulated for the sensor side of the auditory domain. It has been assumed that two simple auditory signals may interfere in the way that two or more musical tones forming a chord are qualitatively different to the individual notes that comprise it, which might be considered to be a form of structural interference. Making two vocal responses simultaneously, on the other hand, is an obvious case of structural interference. It is assumed that most auditory interference effects occur at the higher level of processing (see Table 3) which involve working memory (such as simultaneously speaking and attending to speech).

Table 2. Task interference coefficients (c_{ij}) for a human information processing model — auditory domain.

Channel	*Mode*	*Interference*
Audition	Input	Structural ($\mathbf{c}_{ij}$ = 1 or 0)
Vocalisation	Output	Structural ($\mathbf{c}_{ij}$ = 1 or 0)

CATEGORIES	**CATEGORIES** 0	1	2	3	4	5	6
0. None (no auditory component)	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
1. Tone or simple auditory signal	**0.0**	**1.0**	**0.0**	**0.0**	**0.0**	**0.0**	**1.0**
2. Speech input (*incidental to the primary task*)	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**1.0**
3. Auditory Pattern	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**1.0**
4. Speech input (*attended to*, *salient to the primary task*)	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**1.0**
5. Voice output	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**1.0**	**1.0**
6. No allocation (default)	**0.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**

Cognitive domain

Within the cognitive domain it is assumed that resource limited performance stems from the competition for common processing structures as discussed in connection with the IP/PCT model. Within this domain the degree of interference is graded, with coefficients taking values in the range 0 to 1 (see Table 3 for suggested values). At some level of interference it seems reasonable to assume that operators will perform tasks in a strictly serial fashion rather than resorting to time-multiplexing. <u>The difference between serial and interleaved performance is seen in the position of tasks on the simulated time-line.</u> For interleaved performance, task start times remain unchanged by interference effects, but the completion times of tasks are delayed. With strictly serial performance, one task is postponed until the other has been completed; therefore, there will be changes (delays) in both the task start and stop times. The times required for the tasks to be processed, however, are not modified in this case. Tentatively, this critical value ($\mathbf{c}_{\text{lin}}$) is set at $\mathbf{c}_{ij} \geq 0.7$.

Table 3. Task interference coefficients (c_{ij}) for a human information processing model — cognitive domain.

Channel	*Mode*	*Interference*
Cognition	Central	Resource Limited (see interference matrix — note that structural interference will take precedence over resource limitations, and the maximum value of $\mathbf{c}_{ij}$, over all domains, will be used to determine the outcome)

CATEGORIES	CATEGORIES 1	2	3	4	5	6
1. Automatised, highly learned	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
2. Passive monitoring of auditory signals (e.g., non-salient speech)	**0.0**	**0.0**	**0.2**	**0.0**	**0.1**	**1.0**
3. Verbal encoding, decoding, speech production	**0.0**	**0.2**	**1.0**	**0.2**	**0.5**	**1.0**
4. Spatial encoding decoding, pattern recognition	**0.0**	**0.0**	**0.2**	**1.0**	**0.3**	**1.0**
5. Memorisation/recall, calculation, estimation, deduction, reasoning	**0.0**	**0.1**	**0.5**	**0.3**	**1.0**	**1.0**
6. No allocation (default)	**0.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**

Note that the only interference coefficients that exceed 0.7 in Table 3, are those for which $i = j$ or involve the default category *no allocation*. However, as these are arbitrary assignments, the situation may change in the future. **Note that all operator tasks must be assigned a**

cognitive category. Currently only a single category can be assigned to a task. Further development of IP/PCT concepts in terms of Hierarchical Goal Analysis (HGA) (Hendy, Beevis, Lichacz*, et al.*, 2002) will make the requirement for ANDed cognitive categories imperative in future versions of IPME.

Psychomotor and kinesthetic domains

The Psychomotor and Kinesthetic domain consists of two channels — tactile input and manual output. Interference is assumed to be structural (see Table 4). In general, as *digit* is a subset of *hand*, tasks involving different digits of the same hand will be assumed to interfere. Therefore, selection of *digit* will automatically invoke *hand*. Compatible combinations, such as might occur with Hand-on-Throttle-and-Stick (HOTAS) systems, will be made by exception (see the Section on *Modelling the Allocation of Attention*). Similarly for *Foot* and *Leg*. Keyboarding tasks, such as typing or operating a Control Display Unit (CDU) for a Flight Management System (FMS), involve the whole hand, so the need to consider each digit separately is unnecessary. The operation of rudder pedals and toe brakes is a compatible combination that would be added to the exception list (again see the Section on *Modelling the Allocation of Attention*.).

Table 4. Task interference coefficients (c_{ij}) for a human information processing model — psychomotor and kinesthetic domain.

Channel	*Mode*	*Interference*
Tactile	Input	Structural ($\mathbf{c}_{ij}$ = 1 or 0)
Manual	Output	Structural ($\mathbf{c}_{ij}$ = 1 or 0)

CATEGORIES

Left Hand	Right Hand
None	*None*
Whole hand	*Whole hand*
Digit 1	*Digit 1*
Digit 2	*Digit 2*
Digit 3	*Digit 3*
Digit 4	*Digit 4*
Digit 5	*Digit 5*

CATEGORIES

Left Leg	Right Leg
None	*None*
Whole leg	*Whole leg*
Foot	*Foot*

No allocation (default)

CATEGORIES	YES	NO
Tasks use the same hand, leg, foot, finger, at least one task is not allocated etc.	**1.0**	**0.0**

Categories in this, and only this, domain are currently ANDed for complex tasks such as flight control (see also the discussion on Page 11 related to the future requirements to AND cognitive categories). Hence, multiple category selections (e.g., right hand, left and right foot for a fixed wing aircraft) may be made for this domain.

Miscellaneous domain

A miscellaneous domain (Table 5) is included to account for effects that are not covered adequately by Tables 1, 2, 3 and 4. For example, one may wish to model team activities rather than individual operator tasks, redefine the categories for one of the domains, or introduce a new domain such as aided-vision. The miscellaneous domain provides some flexibility for accommodating additions such as these to the network of tasks. It is possible to edit both the names of the category fields (up to 15) and the name of the table for a specific application. These changes are reflected globally.

Table 5. Task interference coefficients (c_{ij}) for a miscellaneous processing domain.

Channel	*Mode*	*Interference*
Miscellaneous	Unspecified	Structural or Resource limited.

CATEGORIES	CATEGORIES 0	1	2	3	4	5	...	*n*
0. None (default)	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**...**	**0.0**
1. Category 1	**0.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**...**	**1.0**
2. Category 2	**0.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**...**	**1.0**
3. Category 3	**0.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**...**	**1.0**
4. Category 4	**0.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**...**	**1.0**
5. Category 5	**0.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**...**	**1.0**
...		**...**	**...**	**...**	**...**	**...**	**...**	**...**
n. Category *n*	**0.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**...**	**1.0**

Combining interference coefficients

Equations (4), (5), (7), and (8) require a single value of $\mathbf{c}_{ij}$ for the calculation of interference effects. The value of $\mathbf{c}_{ij}$ used finally to describe the degree of task interference is the maximum value of the coefficients obtained from all active domains represented by Tables 1, 2, 3, 4, and 5, and the value of $\mathbf{c}_{ij}$ obtained from any transformations. Obviously structural interference ($\mathbf{c}_{ij} = 1$), when present, will dominate, and will force strictly serial processing. Because all input and output channels (vision, audition, vocalisation, tactile, manual) invoke structural rather than resource limitations, cognition isn't a factor if a source of interference is peripheral. Cognition enters the equation only when peripheral (sensor/effector) limitations are absent.

Combining interference coefficients in this way carries with it the assumption that domains (visual, auditory, cognitive, kinesthetic/psychomotor and miscellaneous) are ORed. Hence, any task might involve processing resources from one or more of these domains. Indeed, all tasks are assumed to have at least a cognitive component. Categories within domains, in general, are not ANDed currently with one exception. The exception is for the kinesthetic/psychomotor domain (see the discussion on p. 11) where tasks might involve various combinations of digits, hands, arms and legs.

With the intention to AND cognitive categories in future implementations of IPME, the value of $\mathbf{c}_{ij}$ used in calculations will be the maximum value of $\mathbf{c}_{ij}$ calculated for all pair wise combinations of the cognitive categories of each task.

Linking peripheral categories with central categories

Various types of input and output processes can be linked naturally with appropriate central processes (see Table 3) as shown in Table 6. Future versions of IPME may make these linkages by default. In most cases the instances of input and output categories listed in Table 6 are already reflected in the interference matrices of IPME. Some new categories and sub-categories have been introduced as follows:

VISION domain

- two sub categories have been added under Central vision,

AUDITION domain

- a new category *Auditory locatisation*,

KINESTHETIC domain

- two new sub-categoies under Tactile

MEMORY domain[1]

- recall from memory is a new domain arising from the move to goal based decompositions of human activities (Hendy, Beevis, Lichacz*, et al.*, 2002).

Table 6. *Natural linkages between input/output and perceptual/central processes.*

INPUT/SENSATION	COGNITIVE/PERCEPTUAL PROCESSES
VISION	
1. Central	
1.1 Text, dial reading	Verbal encoding
1.2 Pattern, spatial relationship, tracking, graphic displays	Spatial encoding, visual pattern recognition
2 Peripheral	Automatised, highly learned perception
AUDITION	
1 Tone or simple auditory signal	Automatised, highly learned perception
2 Speech input (incidental to the primary task)	Passive (pre-attentive) monitoring of auditory signals
3 Auditory Pattern	Semantic (use verbal) decoding.
4 Auditory localization	Spatial decoding
5 Speech input (attended to, salient to the primary task)	Verbal decoding, speech recognition
KINESTHETIC.	
1 Tactile	
1.1 Simple stimulus	Automatised, highly learned perception
1.2 Complex stimulus	Spatial encoding.
MEMORY	
	Automatised
	Verbal decoding
OUTPUT/BEHAVIOUR	
VOICE	
1 Voice output	Speech production
PSYCHOMOTOR	
1 Manual output	
1.1 Simple	Automatised, highly learned response
1.2 Difficult but familiar	Spatial encoding
1.3 Complex and or unfamiliar	Memorization/recall, calculation, estimation, deduction, reasoning

[1] It is not necessary to create a new interference matrix or cofficients for MEMORY as it can be absorbed into the cognitive domain. An input screen for memory would simply be used to link with the cognitive categories identified in Table 6.

Allocation of Attention

In general, a task network could be said to simulate the demand placed on the operator by the system, rather than the task load actually serviced by the operator. A task network can have many parallel branches which lead to the generation of multiple concurrent demands. In many cases these demands clearly exceed human capabilities to respond (e.g., CMC, 1992; Glenn, *et al.*, 1994). While the IP/PCT model posits that many loops can be under simultaneous control, tasks that share common processing resources will compete for processing time. For the reasons stated previously, it has been assumed that no more than 2 high level tasks will be processed concurrently. The purpose of an *allocation of attention* module is to schedule the tasks to be performed, either serially or concurrently depending on their levels of interference, at any point in time. The allocation of attention module determines whether a task is performed on demand, interrupted, resumed, postponed, or shed. The allocation of attention algorithm is intended to provide a fair representation of human task selection strategies under competing system demands.

A rule base for the scheduler

When the task network generates a new demand (with the exception of certain special cases — see p. 18ff.), the following set of rules govern the scheduling of tasks. When new tasks arrive or an ongoing task finishes, a *temporary* queue is generated containing all tasks currently running (the active task list), together with any new tasks and tasks awaiting processing. Tasks awaiting processing are retrieved from a *short term memory* (STM) queue plus a *systems* queue for externally cued visual tasks (see discussion on p. 18). Not all tasks make this transition if memory has decayed (see p. 32 for the details of memory effects). Note also that some externally cued tasks are special cases, both in the condition of their entry into the temporary queue and in their storage during the pre-attentive stage. A task that is programmed to occur in a cyclical fashion (i.e., see the discussion on p. 20 for *continuous* and *repeating* tasks) is not added to the temporary queue if a predecessor remains present in the short term memory queue or in the active task list. Neither will it be transferred to the short term memory queue following the current task scheduling.

Task scheduling is in accordance with the following rules based on *priority*, *interruptability*, *resumability* and *sheddability*. Note that, in general, *priority* might be time or state dependent (e.g., the priority of a display may increase with time since last glance, the priority of a task may change due to the occurrence of some predisposing condition — see discussion on p. 32). Short term memory queue size is tracked. This queue is flushed on a *first opportunity* basis (i.e., as soon as an ongoing task finishes, the queue is examined to see if there are any tasks that can be started). Note that this does not account for physiological or psychological refractory periods which are generally of short duration, compared to the task completion times, and can therefore be ignored.

> *Rule 1*. Tasks transferred from the active task list, which are deemed to be *interruptable*, may be halted if less than C_{crit} complete (tentatively C_{crit} = 70%). An interrupted task is returned to the STM memory queue

(subject to Rule 7) and may be *resumed* (applying the start-up penalty μ as appropriate — see p. 5) or *restarted* later. An *uninterruptable* task, once started, must run to completion (as it is not actually interrupted the start-up penalty μ is not applied). A task which is *not resumable* is *restarted* if possible (note that the time remaining on the task is set back at T_i when it is returned to the STM queue). Task interruptions are logged, non-resumable tasks are flagged when interrupted and the actual percentage processing complete recorded at the point of interruption.

Rule 2. Tasks, including interrupted tasks, are serviced in order of *priority*. Priority is determined by the value of the instantaneous time pressure for the task (see discussion on page 21). All task postponements are logged. Task(s) of the highest priority value(s) are serviced first with the exception of active uninterruptable tasks which take precedence once started.

Rule 3. Once the highest priority task is selected (taking into account the precedence relationship of uninterruptable tasks), if the 2nd ranked task has a level of interference with the first ranked task such that $\mathbf{c}_{ij} \geq \mathbf{c}_{\text{lin}}$, it is returned to the temporary queue and the next ranked task considered. This process is repeated until a compatible combination is found or until the queue is exhausted. For the purposes of starting a task, if it can be performed with an alternate hand, foot, or limb this is tried before rejecting the combination (see Rule 5). This event is logged. If the $\mathbf{c}_{ij}$ resulting from the initial selection is 0, the next highest priority tasks (down to and including Category 8 tasks in Table 8) is added to the current selection(s), in turn, until **any** pairing of the selections results in $0 < \mathbf{c}_{ij} < \mathbf{c}_{\text{lin}}$ (skipping over tasks for which $\mathbf{c}_{ij} \geq \mathbf{c}_{\text{lin}}$).

Rule 4. If several tasks have the same priority they are scheduled according to the following hierarchy:

- in order of their originally scheduled start time (including non-resumable tasks that are restarting), and independent of the number of interruptions;
- in order of the least processing time remaining;
- according to least interference; and
- a random selection is made.

Rule 5. If a task can not be started due to interference effects it is allocated to a less loaded channel if possible. This generally will occur for tactile and manual channels only.

Rule 6. Any remaining tasks in the temporary queue that are category 1 in the cognitive domain (assumed to be automatised or skill-based — see Table 3) are added to the active list provided there are no structural interference effects with the tasks **already** scheduled. Externally queued visual detection tasks (see the discussion on special cases on p. 18ff.), once accepted into the temporary queue, are always added to the active list.

Rule 7. The STM queue is limited to *m* items (tentatively $m = 3$; for example see Moray, 1986, page 40-27) and does not include items in the active task list. On transfer from the temporary queue, tasks are shed from the bottom of the priority list — *sheddable* tasks first — to meet this limit. If the limit can not be met with sheddable tasks, *non-sheddable* tasks are **forced** from the queue (but only after **all** sheddable tasks have been removed). The following hierarchy is used to determine the order of shedding among tasks of equal priority value. That is:

- in order of the most processing time remaining;
- according to most interference; and
- a random selection is made.

Tasks shed are logged. Tasks partially serviced when shed have the actual processing time completed logged (% complete). Repeating and continuous tasks that are shed due to an unprocessed or incompletely processed predecessor, are also logged.

When a task is shed a decision must be made with respect to the linked tasks that follow. Failure to do this will result in a potentially premature termination of a branch or indeed the whole network. When a task is shed (including forcible sheddings) there are 4 potential outcomes:

1. there is no effect on network integrity (no tasks follow);
2. the branch should terminate (the shed task is on a critical path and failure to process the task implies mission failure);
3. the next linked task should be started (this will be the default condition); and
4. another task(s) should be initiated (this might be a deterministic, conditional or probabilistic branching).

Task shedding occurs in response to excessive task-loading, hence it would be inappropriate to start a following task the moment a predecessor is shed. To avoid the propagation of the overload condition through the network, any task linked to a shed task is not initiated until the shed task was due to finish (i.e., time of shedding + $\Delta T_{\mathrm{act}}(n)$). Note that the task status variable *shed* can be used to effect the outcome of future activities in the network through various task performance modifiers (see p. 27ff.). Note also that condition 4 includes rescheduling the task if it branches back to itself.

At the moment the rule base for the scheduler involves crisp sets. Further developments could introduce a fuzzy rule set if this was deemed to be a better model of the human scheduling process. The notion of the human as a fuzzy adaptive controller is a particularly attractive analogue (Mancini, 1988).

Exceptions and special cases

Compatible Task Pairs. There are likely to be pairs of tasks that although predicted to be structurally or resource limited to serial processing (tentatively for values of $\mathbf{c}_{ij} \geq \mathbf{c}_{\text{lin}}$) may be compatible for dual tasking in certain combinations (e.g., controlling aircraft pitch and roll with a joystick or control wheel involves the same hand but is a compatible combination). Allowance is made for these exceptions on a case by case basis. For these selected combinations of tasks, $\mathbf{c}_{ij}$ takes on new values (0 if structurally limited and < $\mathbf{c}_{\text{lin}}$ if resource limited — an internal check ensures that this is so) on a special case basis. This will only effect the $\mathbf{c}_{ij}$ values for these specific task-pairings and will not, in general, effect the $\mathbf{c}_{ij}$ values when these tasks are paired with any other tasks.

Externally Cued Visual Detection Tasks. In general, tasks can be **internally** cued (goal-directed) or **externally** cued (the trigger originating in the environment). Externally cued tasks must first capture the attention of the operator before they can be serviced. The probability of detection of an externally cued visual task will determine the likelihood that the task enters the temporary queue and therefore is a candidate for processing. This allows the location of externally cued visual stimuli to effect the outcome of the task network simulation, say, through the probability of detecting and responding to a new visual stimulus occurring in an area other than the *home* area.

Hence, when an externally cued visual task is generated by the network, the detection component of the externally cued task is added to the temporary queue with a probability that depends on the nature of the task (central, peripheral etc. — see Table 6) and the angular subtense measured either from the *Home* region or from the region of the highest priority visual task currently selected (with central tasks taking precedence over peripheral — see p. 7). The probability value from Table 7 may have a modifier to account for stimuli that decay or otherwise change in detectability (see discussion on p. 31).

Table 7. Probabilities of detection for externally initiated visual detection task.

EXTERNALLY INITIATED CATEGORIES	ANGULAR SUBTENSE (DEGREES) Ø≤ 2	2<Ø<30	30≤Ø<90	90≤Ø≤180
1. Central	**1.0**	**0.5**	**0.0**	**0.0**
2. Peripheral	**1.0**	**1.0**	**0.5**	**0.0**
3. No allocation (default)	**1.0**	**1.0**	**1.0**	**1.0**

Note that it is the responsibility of the analyst to create the detection component of the task activity and correctly designate it as an Externally Cued Visual Task (from the categories in Table 8). The detection component is envisaged as a short duration (500-750ms) automatised task that merely signals the presence of an interesting visual stimulus. These tasks do not contribute to the instantaneous time pressure or occupy cognitive or short term memory resources.

An attempt to add the detection task to the temporary queue is made only after **all** other internally cued task selections have been made — to determine the point of goal-directed vision —but before the selection is implemented. Further attempts are made to add the detection task to the temporary queue, during the time that the visual stimulus is available (subject to the same rules as the first attempt). Until the task enters the temporary queue it is held in **system** rather than **operator** memory. These further attempts to engage the attentional mechanism can be made only when there is a potential shift in visual attention (i.e., when the currently active visual task is completed, interrupted or shed). If the task fails an attempt to enter the temporary queue it is logged as a failure to detect. If the event marking the presence of the signal disappears from system memory before the detection task enters the temporary queue, it is logged as a missed detection. Obviously, if the detection task initiates a network of activities (the localisation, recognition and action initiation stages of the activity) they will be disabled if the detection phase fails. An externally queued visual detection task is serviced immediately, once it has entered the temporary queue (see Rule 3). Other components of the activity (post detection) may require higher level cognitive resources and thus automatic processing can not be assumed. The task components initiated by the detection task are likely to be goal-directed (internally cued) and therefore will not, generally, fall under the special case described here.

Externally Cued Speech and Auditory Pattern Recognition[2]. Externally cued or attended speech input is processed at the time it occurs or shed. Speech inputs will, generally, be externally cued (i.e., their time of occurrence is under the control of the speaker rather than the listener). It is assumed that signal to noise ratios are such that the presence of these speech signals passes the detection phase even if it is not possible to attend, due to higher priority concurrent tasks, at levels of processing such that the information content is transferred.

Therefore as these tasks are assumed to pass the detection phase, they are added to the temporary queue as soon as they are generated by the network. Giving them Category 1 priority (see Table 8) makes them candidates for instant processing. They do not go into interim storage in system memory. Hence, speech is either processed at the time of arrival or forcibly shed from the queue and logged as a missed communication. There is no attempt to reschedule at a later time if the task is not serviced immediately due to the tie breaking provisions of Rule 4 of the scheduler or the presence of tasks with $TP > 1$. Hence, those tasks designated as Category 2 and 4 from Table 2 are, if externally cued, shed on the first attempt to transfer from the temporary queue to the short term memory queue. These tasks are shed

---

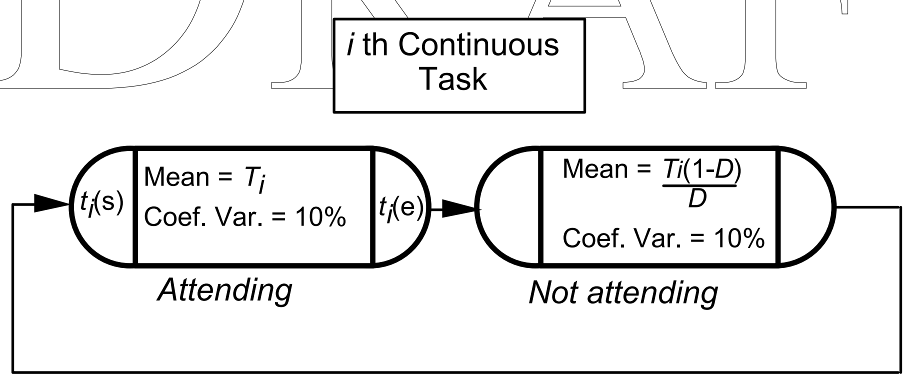
[2] **Internally Cued Speech Input and Auditory Pattern Recognition.** Speech and auditory pattern recognition tasks might also be internally cued (i.e., under the control of the listener). These tasks are treated as any other task, rather than under the special case provisions discussed above. That is, they enter the temporary queue at the time of occurrence and are transferred to the STM queue for later processing, under the rules of the scheduler, if they cannot be serviced immediately. The rules associated with continuous and repeating tasks are invoked as appropriate.

before pruning the remaining tasks in the temporary queue down to the short term memory queue limit of *m* items. Auditory pattern recognition tasks designated as Category 3 in Table 3 are, **if externally cued**, treated in the same way as the equivalent speech input.

Continuous and repeating tasks

Notionally continuous and repeating tasks are identical. The IP/PCT model treats continuous tasks as repetitive cycles of attending and not attending (Hendy, 1994b). It is assumed that, on average, the proportion of any given time interval required for the active processing of a continuous task, to achieve criterion performance, is directly proportional to the rated difficulty of the task. Hence, for continuous tasks, the average duty cycle is set by the difficulty rating D, where $0 < D \leq 1$. The mean time interval required for active processing, during each cycle, is set by the analyst. A default value of 0.5 second is used for this dwell time, with a default coefficient of variation of 10%, and a duty cycle of 50% (a Beta, instead of a Normal, distribution could be used, in which case maximum and minimum values would be set). Hence, the network representation of a continuous task is shown in Figure 3. The starting and ending times for continuous tasks may be set by external factors such as the mission scenario, or from internal network states such as the activation of another task or some parameter taking a particular value or range of values.

Repeating tasks are treated similarly except that the *Attending* time and the mean *Cycle* time is set directly rather than through an intermediate parameter such as D. Hence, given that the mean *Attending* time of the *i*th repeating task is T_i, and the mean *Cycle* time is δT_i, then the mean *Non attending* time is $\delta T_i - T_i$.



t_i(s) start time for continuous task *i*

t_i(e) end time for continuous task *i*

D rated task difficulty (0 < *D* Š 1)

***Figure 3.* Network representation of a continuous task. A repeating task differs only in the calculation of the mean non-attending time.**

Task Priority

Suppose tasks have associated with them a latest acceptable time for servicing ($t_i(\mathrm{L})$). This time might be related to the importance of the task to mission success, to an external event in the scenario, or to the status of certain variables in the network. The latest acceptable time for servicing is calculated once only (with one exception discussed below), when the task first arrives for servicing — it does not change with interruption and resumption cycles including tasks that are restarting (even though T_i is recalculated).

Peak instantaneous time pressure

At any point (t) in time, after its generation by the network, the *instantaneous time pressure* associated with the ith task is calculated as the ratio of

$$\frac{\text{effective processing time remaining on task } i}{\text{time remaining to latest processing time for task } i}.$$

or

$$100\left[\frac{\Delta T_{eff}(n)}{t_i(\mathrm{L})-t}\right]\%. \tag{11}$$

This process captures the essence of the *time available* part of the time pressure calculation in the IP/PCT model.

Task shedding and tasks that are late

The *peak instantaneous time pressure* is the maximum time pressure value found for all tasks in the short term memory queue plus the active tasks. It is assumed that subjective reports of workload will be related to a moving average of the peak instantaneous time pressure calculated over the most recent load history.

If $\Delta T_{eff}(n) > t_i(\mathrm{L}) - t$, the instantaneous time pressure exceeds 1 for that task and it might be forcibly shed, or be logged as late and retained in the STM queue for future servicing. If it is deemed that the task should be forcibly shed, this condition overrides any other restrictions (see Table 8) that might be operating. These tasks are flushed from the temporary queue once the criterion has been met, that is as soon as the *TP* value is calculated and before the current processing interval proceeds. This establishes the time at which task shedding occurs.

If the task is not forcibly shed, the current task status is set to *late*, and a variable is set to TRUE. The same conditions apply when $t \geq T_i(\mathrm{L})$ with one exception. If the task is finally serviced with an actual start time that is later than or equal to the previously calculated latest processing time $t_i(\mathrm{L})$, a new $t_i'(\mathrm{L})$ is calculated with respect to the actual start time that is equal to $\left(t_i(s) + T_i\right)$. This sets the initial value of the time pressure at $TP = 1$ and makes the task a candidate for immediate processing. These are the only conditions under which the latest processing time is recalculated.

A variable is set TRUE the first time the satisfying conditions apply for the task. It is not modified if these conditions subsequently change, for example, due to the recalculation of $t_i'(L)$ or if the task is forcibly shed on a future cycle. The task status variable always tracks the current state of the task.

Latest acceptable time for servicing continuous and repeating tasks

For continuous tasks the expected arrival of the next *attending* interval sets the latest processing time for the purposes of calculating instantaneous time pressure. Hence, for the *n*th occurrence (arriving at time $t_{in}(a)$) of the *i*th continuous task with rated difficulty level D_i, the expected latest arrival time is given by

$$
\begin{aligned}
\overline{t_{in}(L)} &= t_{in}(a) + T_i + \frac{T_i(1 - D_i)}{D_i} \\
&= t_{in}(a) + \frac{T_i}{D_i},
\end{aligned}
\tag{12}
$$

while for the *n*th occurrence of the *i*th cyclical task,

$$
\overline{t_{in}(L)} = t_{in}(a) + \delta T_i. \tag{13}
$$

Task categories and priorities

In Table 8, tasks are categorised according to their time criticality. This categorisation establishes the initial priorities and time pressures for all tasks. For all tasks *interruptability* is temporarily disabled if the instantaneous time pressure for that task equals or exceeds a value tentatively chosen to be 0.8. This is the minimum value for the non-interruptable tasks designated as categories 1 to 3 in Table 8.

<u>Tasks nominated as *sheddable* do not contribute to the calculation of peak instantaneous time pressure</u>. These are discretionary tasks and therefore do not logically have a $t_i(L)$ associated with them[3]. This is really only an issue with the Category 5 and 7 tasks in Table 8 that may be nominated either as *sheddable* (in which case a $t_i(L)$ would not be calculated) or *non-sheddable*.

---

[3] For the sake of convenience in coding, Category 7 and 8 tasks designated as *sheddable* are given an arbitrary instantaneous time pressure, and therefore priority, of 0.001 rather than 0. This allows *sheddable* tasks to time multiplex with each other and avoids dividing by zero in Equation 6.

Table 8. Categorisation of tasks according to their latest processing times $t_i(L)$.

CATEGORY	TASK CHARACTERISTICS	$t_i(L)$	INTERRUPTABLE	SHEDDABLE
1	Requires instant reaction. Is critical for crew survival. No delays or interruptions are acceptable. Includes externally cued auditory tasks.	$t_i(a) + T_i$	No	No¥
2	Requires priority attention. User defined delays between 0 and 25% of the task completion time. No interruptions are acceptable.	$t_i(a) + \kappa T_i$ $1 < \kappa < 1.25$	No	No
3 (default)	Requires priority attention. Delays of up to 25% of the task completion times are acceptable. No interruptions are acceptable.	$t_i(a) + 1.25T_i$	No	No
4	User defined delays in excess of 25% of the task completion time. Tasks may or may not be interruptable. Important Routine	$t_i(a) + \kappa T_i$ $\kappa > 1.25$ $\kappa = 1.5$ $\kappa = 1.75$	Yes†/No	No
5	Latest time for task completion is set by the scenario. Tasks may or may not be interruptable or sheddable.	set externally	Yes†/No	Yes/No
6	Continuous task with rated difficulty level of D_i.	$t_i(a) + \frac{T_i}{D_i}$	Yes†/No	No§
7	Repeating task with mean attending time T_i and mean cycle time ∂T_i.	na€/$(t_i(a) + \delta T_i)$	Yes†/No	Yes/No§
8	Low priority. May be interrupted or shed.	na€	Yes	Yes
9	Externally initiated visual detection task.	na	No	No‡

Notes for Table 8:

¥ *Externally cued speech and auditory pattern recognition tasks will be forcibly shed if they are not processed immediately as special cases of this category. Shedding occurs at the beginning of the processing interval*.

† *Depends also on the value of the instantaneous time pressure. When the instantaneous time pressure for the task exceeds 0.8 task interruptability for this task, if enabled, should be disabled. Interruptability is also disabled when a task is ≥70% complete. Neither of these rules will apply to Category 8 tasks*.

€ *See footnote on page 22. Instantaneous time pressure is arbitrarily set at 0.001 for all sheddable tasks.*

§ *Whenever it's predecessor remains unprocessed, a repeating or continuous task will be shed. Shedding occurs at the beginning of the processing interval*.

‡ *Put in a temporary* ***system*** *queue (rather than* ***human*** *memory) if not serviced at the first opportunity. Finally shed if not serviced during the time the stimulus is present*.

Task priority for the attentional mechanism is computed from the closeness of the current time to $t_i(L)$ with **tasks having the highest instantaneous time pressure being serviced first** (see Eq 11). Higher priority tasks also capture more of the processing time when competing with other tasks. The probability estimates for time-multiplexing the processing channel use normalised data and can therefore handle *priority* values (instantaneous time pressures) greater than 1.

For the detection part of an externally cued visual task the issue is whether the stimulus was detected or not, rather than the priority of the task (detection is assumed to be pre-attentional). <u>Hence, these tasks do not contribute to the instantaneous time pressure or occupy cognitive or short term memory resources</u>. Once the detection is made, however, a string of tasks might follow which do load memory and contribute to the instantaneous time pressure. Because of the special status of the visual detection task it is given its own category in Table 8. <u>Note that task shedding, if detection fails during the time the stimulus is present, is from the system memory rather than human memory</u>.

By giving externally cued speech and auditory pattern recognition tasks Category 1 status in Table 8, they enter the temporary queue with the highest initial priority and therefore are candidates for immediate servicing.

Because the effective time remaining on resumable tasks is increased by a factor μ when interrupted, the priority of a resuming task is effectively increased slightly due to an increase in the instantaneous time pressure (e.g., see Davis, 1971). This is over and above the increase in time pressure that results from any delays in task completion.

Predicting Operator Workload and Performance

The IP/PCT model posits that operator load depends on the *time pressure*, or the ratio of *time required to process information* to the *time available*. In the context of task network simulation, the time required to process information is given by the task completion time of each activity. The concept of time pressure represents a return to a metric that has a long history in time-line analysis and task network simulation (e.g., see Linton, Plamondon, Dick, *et al*., 1989). The major difference between the current implementation and past usage, with the exception of Wingert's function interlace method (Wingert, 1973), is that with the current implementation performance is sensitive to the presence of multiple concurrent tasks.

As an alternative to the percent time occupied prediction of operator workload, the value of the peak instantaneous time pressure across all active and memory queued tasks — actually a moving average over its recent time history — is used . This measure is directly related to the notion of time pressure as used in the IP/PCT model, namely the ratio of the actual processing time to the time available. In the words of Linton, *et al.* (1977) "...As used by many systems engineers, workload is the extent to which an operator is occupied by a task relative to the time that is available for accomplishing the task."

Unlike the *percent time occupied* metric, an *instantaneous time pressure* measure retains its sensitivity to the composition of the task time-line even when the network is entirely task-driven. Hence while the percent time occupied metric might speak to the *busyness* of the simulated operator, a moving average of the peak instantaneous time pressure is likely to be more closely related to the operator's perceived task-loading. Because sheddable tasks do not have a latest processing time associated with them, they do not effect the instantaneous time pressure value unless these tasks change status either permanently or temporarily. The IP/PCT model uses the average mean peak instantaneous time pressure as the predictor of operator workload.

Specifying the point of overload

While not strictly necessary for purely comparative studies, the specification of a load limit (a *redline*), for defining the point of operator *overload*, tends to be the Holy Grail of workload researchers. Typically, values around 70 to 80% *time-occupied* are chosen. These values appear to be supported by little more than observations that this marks the point at which load shedding starts. However, empirical evidence is not offered in support of these claims (Meister, 1985, p. 78).

For purposes of illustration, suppose that the problem is framed in terms of a single server queuing problem (Campbell, 1989). Note that in the IP/PCT model, the single server is sometimes taking customers two at a time. In this situation, some predictions might be made as to what would constitute a point of overload. If tasks are assumed to arrive according to a Poisson process at a constant mean rate λ tasks s^{-1}, and the mean task completion rate also remains constant at a value of μ tasks s^{-1} (assume task completion times are exponentially distributed), then, in a given fixed time interval δt

mean time occupied = mean number of tasks × mean task completion time

$$= \delta t \lambda \mu^{-1}, \text{ and}$$

mean time pressure

$$= (\delta t \lambda \mu^{-1}) \delta t^{-1}$$

$$= \lambda / \mu \,.$$

Equating λ with the mean arrival rate of the queuing problem, and μ with the mean service rate (Hillier and Lieberman, 1974), it can be seen that the mean *time pressure* is equivalent to the *utilisation factor* ρ of the queuing problem. For a classical single server system, the steady state number of items in the queue is 1 at $\rho = 0.5$, rising to approximately 2 at $\rho = 0.7$, and 4 at $\rho = 0.8$ (Hillier and Lieberman, 1974, Fig 9.6). If the queuing analogy is valid, it seems that a value of *time pressure* around 0.75 is a reasonable limit to set. This would hold the steady state queue size to 2-3 items.

Memory queue size and task shedding

The issue of setting limits on time pressure assumes less importance if overload is redefined in terms of the length and status of the short term 'memory' queue in the allocation of attention module. Of particular interest are occasions of forceful load shedding from this short term storage. This approach strikes directly at what might in fact be the underlying problem of operator overload, and avoids problems associated with the arbitrary selection of parameters for the moving average, particularly in the case of the time occupied metric. In view of the need to distinguish between discretionary and non-discretionary tasks when computing operator load, this shift from a traditional workload paradigm to a concern for tasks serviced versus tasks shed is particularly salient.

Basically the analysis shifts from a concern for *workload* to an interest in *errors* (task shed, delayed etc.) and the development of system status knowledge by tracking the proportion of tasks serviced that contribute to situation assessment. Using this approach, task shedding is tracked and categorised by the type of information involved. Flags distinguish between tasks that are critical to mission performance, and those that contribute to awareness of the mission of the system. Note that in the IP/PCT model, operator error is associated with information unprocessed or shed (Hendy, *et al.*, 1997).

Task Performance Modifiers

Task network simulation has the potential to be sensitive to a number of task performance modifying influences such as: manpower (crew size), personnel (aptitude, command, experience) and training (knowledge, skills) issues; fatigue and other physiological stressors; allocation to an alternative processing channel (another sensory channel or operator); operator adaptation to high information processing loads; and various psychological stressors. The network properties that are available to implement this potential are (Hendy, *et al.*, 1992):

- individual task inventory;
- task attributes;
- task sequence, including branching due to conditional or probabilistic task outcomes (e.g., resulting from a changed probability of successful task completion);
- task completion time; and
- tasks serviced and shed.

In this Section, a number of TPMs are advanced to account for the effects of:

- time pressure and channelised visual attention;
- memory;
- predecessor tasks;
- changing priority values;
- aptitude and experience;
- physiological/psychological stressors; and
- the use of non-preferred channels.

These effects are assessed for their influence on: task inventory and sequence through the probability of successful completion and detection probabilities; task completion time; and task attributes such as *priority* and *domain category*.

It is realised that the application of multiple factors has the potential for unwanted cumulative effects. An attempt has been made to resolve the most obvious conflicts by clearly establishing rules for combining multiple factors that effect task completion times or probabilities. At this stage, to implement a starting suite of task performance modifiers, it is sufficient to provide access to certain system variables such as:

- number of interruptions for each task;
- the (mean) instantaneous time pressure;
- time since the task segment commenced;
- a list of active tasks and tasks in the short term memory queue;
- number of unsuccessful scheduling attempts for each task;
- % processing completed on each task;
- status of a specific task;
- elapsed time since first scheduled start time of each task; and
- categories (from Tables 1, 2, 3, 4, and 5) of all tasks in the queue.

Where these task performance modifiers effect bounded variables, a check is made to see that parameter values do not stray outside of their limits, for example

- probability values remain in the range {0,1}
- category values stay within the range for the parameter etc.

The default condition is that all task performance modifiers are initially disabled (see Tables 10 and 11). An operator level selection enables the respective TPM in all tasks where the effect has been selected **on**. A task level selection applies at the local level alone. That is the TPM is called up for that task if, and only if, the operator level switch is also enabled for that class of TPMs. <u>In all cases, where time pressure is used to establish the value of TPMs, the mean peak instantaneous time pressure value is used.</u>

Changes in strategy due to time pressure

According to the IP/PCT model, at some critical point, as time pressure increases towards 1, operators will attempt to adopt less accurate but more timely strategies (this is the classical speed/accuracy trade-off). Typically this will involve a reduction in the monitoring of outcomes from emitted behaviours. Hence while task completion time might decrease as a function of *TP*, the probability that the loop has been closed to the desired level of accuracy is expected to decrease also. This could be represented in task network simulation terms by associating probabilistic outcomes with all tasks, or at least with a subset of the task inventory (see Figure 4).

In Figure 4 each task has two potential outcomes. In one case it is assumed, with a probability *p*, that the goal has been achieved to the required accuracy. This is the notion of a task *successfully completed*). Alternatively, with a probability (1 - *p*), it is assumed that the required accuracy has not been met and the task is considered to be *unsuccessfully completed*. In Figure 4 a task performance modifier $\mathrm{tpm}(\overline{TP})$ for task completion time and the probability of goal achievement are both shown to be functions of the time pressure. The critical value TP_{crit} at which the simulated operator attempts to adapt to increasing time pressure by a change in strategy (e.g., see Sperandio, 1978; Seifert, 1980) might be associated with the 70-80% *redline* value discussed previously.

Category 1, 2 and 3 tasks in Table 8 are exempted from this speed accuracy trade-off as it is assumed that these tasks will always be performed in the most expeditious manner. Any automatised skill-based tasks (Category 1 for the cognitive channel — see Table 3) are also exempted. TP_{crit} is set by the analyst with a default value of 0.7.

The Task Performance Modifier (TPM) shown in Figure 4 can be used to change the 'native' task completion time (T_i) of a task as follows. Let the working value for the task completion time of the *i*th task (T_i'), computed at the time an attempt is made to service the task, be given by

$$T_i' = \mathrm{tpm}(TP)T_i .$$

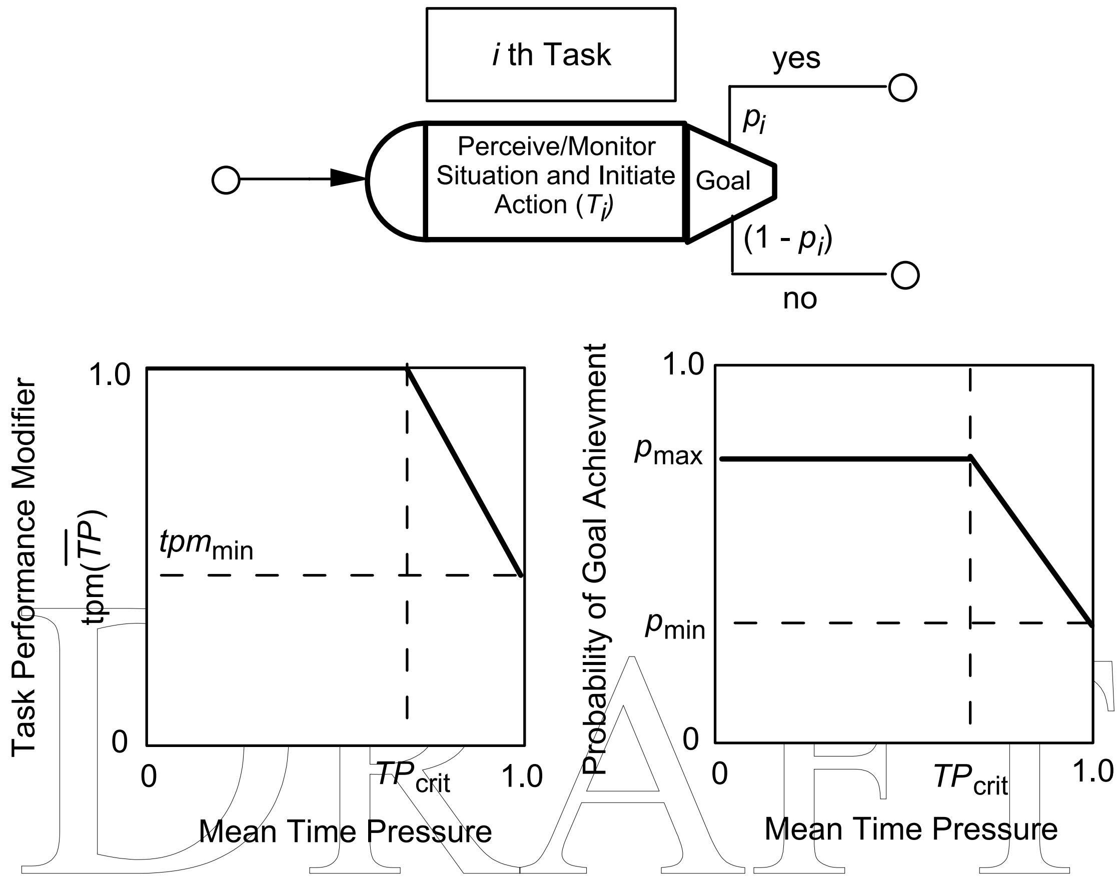


Figure 4. **Incorporating the PCT effects of changing strategies on task completion times and the probability of goal achievement through a Task Performance Modifier.**

TP is the peak instantaneous time pressure (or a mean of the peak instantaneous time pressure— see the discussion in the following paragraph) immediately preceding the time at which an attempt is made to service the task, and $\mathrm{tpm}(TP)$ is a time pressure dependent task performance modifier which is bounded in the range 0 to 1. T_i is the run time value for the current call of the *i*th task, and therefore is a product of the statistical distribution underlying the calculation of task completion times for that task.

Once a task is started T_i' **is not** recalculated if the task is interrupted and **resumed.** However**,** T_i' **is** recalculated if the task is interrupted and **restarted**. Obviously this correction is applied before the tasks are sorted in order of priority. Implementation of this feature requires that an interim value of the peak instantaneous time pressure (or the mean of the peak instantaneous time pressure — see below) is calculated at the time the temporary queue is created (i.e., each time the scheduler is called) purely for the purpose of computing the value of this (and perhaps other) task performance modifier(s). This value (either the raw or mean peak instantaneous time pressure value) is discarded once $\mathrm{tpm}(TP)$ is calculated. It does not modify the time pressure value that is associated with operator load. That is based on the value obtained by using the calculated T_i' for this task. The correction for the effective time remaining, discussed previously (see p. 5), is applied if the task is subsequently interrupted.

It seems to be a reasonable assumption that the human will respond to global rather than local, or individual task, demands. Therefore, task performance modifiers are calculated from a moving average of the peak instantaneous time pressure. This creates the potential for generating a hysteresis effect (or a sustained performance decrement following a peak load), such as has been observed in various time critical tasks (Cumming and Croft, 1973; East, 1993; Hicks, 1993; Smolensky, 1990). Because the moving average retains historical information from recently experienced periods of high load, the 'perceived' time pressure will be higher than the actual time pressure until the moving average has time to decay. This will keep performance from recovering when the load is relaxed due to the action of the time pressure related task performance modifier. The window for the moving average is set by the analyst, with a default value of 1 minute. It is possible to set the width of the window for the moving average down to zero.

In Figure 4 the task completion time and the probability of successful goal achievement trade-off in a linear fashion once the critical value of time pressure is exceeded. It is more likely that changes in strategy would be reflected by one or more step changes in these parameters. For example, a two state model might be

If $\overline{TP} \leq TP_{\text{crit}}$ then

$$T_i' = T_i$$
$$p_i' = p_i$$

else

$$T_i' = \vartheta T_i$$
$$p_i' = \psi p_i$$

end if

where, $0 \leq \vartheta, \psi \leq 1$ are constant multipliers.

If the possibility for many small changes in strategy exists, a linear model may be a reasonable approximation. Both linear and non-linear forms are included for flexibility. Therefore, in general,

IF $\overline{TP} \leq TP_{\text{crit}}$ THEN

$$T_i' = T_i$$
$$p_i' = p_i$$

ELSE

$$T_i' = \text{tpm}_1(TP)T_i$$
$$p_i' = \text{tpm}_2(TP)p_i$$

END IF

When the outcome of goal achievement on task completion is *no* (setting the *unsuccessful completion* flag) the result may be to repeat the task (this is not the same as interrupting the task and restarting), this time with the task performance modifier due to time pressure set to 1 and the probability of goal achievement set to $p_{\max}$ (i.e., reverting to the more accurate but slower strategy). The *no* path may simply rejoin the main network, or, alternatively, initiate a whole new pathway through the network. The value of the status variable can be used at a later date to modulate the future course of the network. For example, the outcome of a future activity might depend on the successful completion of the current task. In essence these are the same types of outcomes that result from task shedding with the exception that network flow is not necessarily interrupted by an unsuccessful task completion. Therefore task shedding can be seen as a special case of unsuccessful task completion. Note, however, that a task might invoke either effect depending on the circumstances.

Probability of detection and channelised attention

As time pressure increases operators often channel their attention and become less sensitive to events occurring outside their primary focus. This concept is already built into the implementation for the visual channel where a high task-driven load will capture attention away from the *home* region which can effect the probability of attending to a subsequent visual task if detection is made conditional on the current visual focus. With stochastic scheduling, the probability that an arriving visual task can be attended to depends on the mean time during which the visual channel is allocated to other visual tasks during the expected arrival time of the new task.

In contrast, the probability of attending to a new visual or auditory task could also be made conditional on the value of the mean peak instantaneous time pressure. This represents an attempt to model the inhibitory effect of high task-loading on the attentional mechanism. This effect is seen to be acting pre-attentionally and therefore overrides any prioritisation due to time pressure as it prevents the task from being added to the short term memory queue. For vision, this is easily accommodated by making the delimiting values in Table 7 functions of the time pressure. For example, the *p*-values in Table 7 could be modified as follows

$$\text{probability of detection(see Table 2)} = p \times \text{tpm}(\overline{TP})$$

Alternatively, for stimuli that decay with time

$$\text{probability of detection(see Table 2)} = p \times \text{tpm}(\delta t),$$

where $\text{tpm}(\delta t)$ is some function of the time since the stimulus first occurred (typically an exponential decay function).

Memory

Several interesting possibilities for modelling human performance flow from the scheduling algorithm. For example, the probability of a successful outcome for some tasks may decrease if they are interrupted or delayed, or a task may be dropped from the queue (forgotten) if not serviced within a certain time period — most likely the probability that an item is forgotten would increase with time or the nature of other tasks in the queue (see the discussion on memory in Card, Moran, and Newell, 1983).

A reasonable starting point is a simple memory model that forcibly sheds a task from the STM queue, with a certain probability, rather than transferring it to the temporary queue whenever a new task arrives or an ongoing task finishes. An exponential decay model is used as the default, namely

$$\text{probability of shedding} = \left(1 - 1.3591e^{-t/\sigma}\right)$$

where t is the elapsed time (in seconds) since the task was first scheduled to start, and σ is the memory decay time constant (i.e., the time to $p = 0.5$). It is possible for the analyst to program other relationships.

Predecessor tasks and task history

As time pressure increases, task shedding will become more prevalent. In the IP/PCT model, error is assumed to depend on the amount of relevant information presented but left unprocessed. At the level of task description used in most network simulations (rarely lower than the button pushing stage) tasks are usually considered completed or not. However, either the time to complete and/or the probability of successful completion of some tasks may depend on the successful completion of various predecessor tasks. For example: the time to respond to an emergency may depend on the extent to which systems states have been monitored recently; a radio can not be set unless the message giving the channel setting was attended to etc. In the initial implementation of the IP/PCT model, the outcome of a task can be conditional on the successful completion of predecessor tasks. The modifying expressions are assembled from standard algebraic and logical relationships.

Task category transformations

Under certain conditions one might wish to modify the initial priority values of one or more tasks. The IP/PCT implementation supports transformations various transformations that may be applied to change task categories during run time. Note that these transformation will effect only the calculation of $t_i(\mathrm{L})$. The originally assigned values of *interruptability* and *sheddability* are retained. Note that *interruptability* is automatically disabled when the time pressure exceeds a critical value or when the task is greater than a certain percentage complete (see notes for Table 8). Note also that the values of these parameters are set by the analyst, with defaults of 0.8 and 70% respectively.

Experience and aptitude

The IP/PCT model posits that different levels of experience, knowledge etc. result in different choices of strategies for processing, which effects both the total amount of information to be processed (hence the processing time) and the processing structure involved (from automatised, perhaps dedicated, structures to algorithmic problem solving involving calculation, recall, use of working memory etc.). These effects could be modelled within a task network environment by changing the task completion times by an appropriate factor and changing the cognitive category of some tasks from Category 1 (Automatised) to Categories 4 or 5 (spatial encoding decoding, pattern recognition; or memorisation, recall, calculation, estimation, deduction, reasoning) and from Category 4 to Category 5.

The experience and aptitude values are set at the level of the operator. The actual tasks that are effected by experience and aptitude factors are set at the local or task level. Transformations are not available for editing locally unless the effect is enabled at the task level. Although simple scalar multipliers are shown in the examples above, more complex functional relationships are possible using the suite of logarithmic, trigonometric and polynomial functions available.

Non-preferred channel

When a task is allocated *a priori* to a preferred processing channel (e.g., a limb or digit) it is assumed that a time penalty may occur if it is re-allocated, at run time, to a non-preferred channel (e.g., performed by the left rather than the right hand). Initially a fixed penalty of 10% is assumed (this is the default relationship). Later more elaborate rules may be developed that are dependent on the target for re-allocation.

Physiological and psychological stress factors

Various physiological and psychological states (temperature, noise, vibration, g-stress, chemical agents, drugs, fear, fatigue, anxiety, motivation, etc.) may work singly or in combination to change task completion times and possibly effect the strategies used to solve problems (the IP/PCT model). This mechanism allows the possibility for linking task models with physiological models (Jensen, 1994). In the simplest form, environmental stressors could be linked to events in the scenario which drive the task network. For example, temperature could increase during a mission, g-stress could be introduced to all tasks associated with an air-to-air engagement etc.

For the IP/PCT model implementation five unspecified physiological stressors may be assigned to each task. The variables are assigned names at the operator level, for example:

stressor (1) = acceleration,
stressor (2) = temperature,
stressor (3) = vibration;
stressor (4) = fatigue
stressor (5) = etc.,

but are given values at the local or task level (these might be discrete values or derived from a functional relationship driven by network time or the attributes of another task). Whereas the values of the stressors are most appropriately set locally (they are task specific), the task performance modifiers that use these values are defined at the operator level (in the sense of specifying functional relationships etc.) and modified locally at the task level if appropriate. The physiological stressors can be used in TPMs.

As an example of a functional relationship, CREWCUT multiplies task completion times by a factor which is a function of the time on task to account for fatigue, as follows;

$$\text{tpm}(\text{fatigue}) = \frac{1}{\left[0.25\left(0.93^{t}\right) + 0.75\right]}$$

where t is the number of hours of steady task performance. For those tasks that have a probabilistic outcome, error rate may be effected also. This relationship is given for demonstration purposes only. Other mathematical forms are possible.

Combined stressors

It cannot be assumed that stressors in combination will act either synergistically or antagonistically. It is likely that complex interactions will occur and the implementation allows freedom for user defined functions and relationships to be inserted, based on standard mathematical and logical forms. Later, fuzzy rule sets may be seen to be more appropriate.

For the current implementation, it is assumed that modifying effects are additive whenever they effect completion time (this will be the default condition and possibly reflects a ‘worst case’ situation). Hence the original task completion time is multiplied by a factor which represents the sum of the percentage changes called for by all individual active stressors. For example, if

tpm(stressor 1) = 1.15 (+15%)
tpm(stressor 2) = 0.95 (-5%)
tpm(stressor 3) = 1.07 (+7%)
etc.

then

$T_i' = 1.17T_i$ (15% - 5% +7%...).

Probabilities are multiplicative.

Application and implementation of TPMs

Generally the transformations described in the preceding discussion are applied whenever a task first becomes available for processing. In some cases the transformations are applied each time the allocation of attention module is called. It is not intended, in general, that the transformations would be recursive in cases when there are multiple calls during the time a task is active or queued waiting for processing time. To avoid compounding the results of successive transformations, the original values of all task parameters are used each time the task performance modifier is calculated. The following Table specifies the conditions that govern the application of the task performance modifiers discussed in this Section.

While the desirability of having a general algebra available for building these transformations is appealing, interactions with other parts of the model and the need to prescribe combination rules limits the choices. Table 9 lists the variables that are to be effected by the task performance modifiers. These are limited to task completion times, the probability of detecting a visual stimulus, the probability of a successful task outcome, probability of shedding a task from the STM (forgetting), and finally task attributes such as priority and domain category.

Table 9. Application of transformations involving Task Performance Modifiers in the IP/PCT model.

		Applies whenever the Allocation of Attention Module is called	
Task Performance Modifier due to	**Applies at Task Start**	**At Beginning of Processing Interval**	**At End of Processing Interval**
Aptitude/Experience	Yes		
Non-preferred Limb	Yes		
Physiological/Psychological Stressors	Yes		
Task History	Yes		None Applicable in this implementation
Time Pressure(speed/accuracy)	Yes		
Memory		Yes	
Task Priority Transformations		Yes	
Time Pressure(visual detection)		Yes	

			Applies to		
Task Performance Modifier due to	**Task complet. time**	**Prob. of detection (Table 7)**	**Prob. of Success (p. 28)**	**Prob. of shedding (p. 32)**	**Task attribute**
Aptitude/Experience	Yes		Yes		Yes
Non-preferred Limb	Yes		Yes		
Physiological/Psychological Stressors	Yes		Yes		
Task History	Yes		Yes		
Time Pressure(speed/accuracy)	Yes		Yes		
Memory				Yes	
Task Priority Transformations					Yes
Time Pressure(visual detection)		Yes			

This page intentionally left blank.

DRAFT

Discussion

This document outlines the implementation of an information processing (IP/PCT) model for use in task network simulations. This implementation includes a representation of the operator's allocation of attention and human memory, together with a framework for tracking the load on the operator's information processing system. The framework for this implementation is provided by Hendy, *et al*.'s (1997) IP and Powers' (1973) PCT models. In positing that human information processing load is determined by the ratio of *time required* to *time available*, the IP/PCT model returns to an approach which has many precedents in the history of task network simulation. However, in recent years classical time-based predictions of operator load have largely given way to procedures that attempt to apply the tenets of resource theory to the problem. Current resource-based techniques owe much of their inspiration to the original work of Aldrich, *et al.* (1984) which in turn has its roots in Wickens' Multiple Resource Theory (Wickens, 1992, p. 375). These methods largely grew out of an attempt to address deficiencies seen to exist with the traditional time-based approach. These deficiencies include:

- the lack of a theoretical underpinning for the T_r/T_a ratio;
- a limitation to serial processing, with the exception of Wingert's (1973) function interlace method — alternatively the inability to discriminate between single and multiple task performance;
- the insensitivity of time-based methods to the difficulty of continuous tasks; and
- the necessity to treat continuous and discrete tasks separately.

The IP/PCT model as implemented in IPME answers each of these criticisms. Firstly, the IP/PCT model provides the theoretical framework for claiming time pressure is the primary driver of operator workload, performance and errors. Secondly, the concept of interference in multiple task performance is implemented through the interference coefficients of Tables 1 to 5. Finally, by treating continuous tasks as repetitive discrete activities, the problems associated with the difficulty of continuous tasks and the combination of continuous and discrete tasks are addressed.

The introduction of an allocation of attention module allows the focus of the IP/PCT model implementation to shift from solely being that of *workload*, to having a greater emphasis on operator *performance* and *error*. In competitive systems (e.g., most military systems) the operator is likely to be always maximally (100%) loaded, as survival in a hostile environment may depend on constant information processing. The issue then becomes '...loaded with what?' For example, how much time does the operator have to scan the outside scene for targets, how much time is devoted to systems monitoring and navigational updates etc? Hence, the issue for the designer is not so much to reduce the workload imposed by the system, but to maximise the level of performance attainable at a given level of operator information processing capacity. The IP/PCT model implementation attempts to give that insight by tracking the tasks actually serviced in times of excessive task-loading.

Neither the IP/PCT model, nor the implementation of that model described in this report, can be considered to be all-encompassing. There will be many aspects of human behaviour that do not fall within the purview of the model and indeed these may be determined more by the nature and limitations of task network simulation than by the structure of the information processing model itself. While these gaps are lamentable, to the extent that they cannot be addressed by fine tuning the model, the IP/PCT model should be evaluated in terms of the following criteria.

Firstly	Is the IP/PCT model either better than alternative models that satisfy the constraints of the task network simulation environment, or is it at least as good and simpler to implement?
Secondly	Is the final product good enough to provide cost effective and useful predictions that might result in better systems design?

Arguably the IP/PCT model satisfies the first criteria. Its assumptions can be traced to a rational theoretical framework, although the final arbitration must wait until competing models can be fully tested in some type of common environment.

The advantages of a structured approach to front-end design, of which workload/performance prediction is a component, is generally accepted. Therefore if the IP/PCT model passes on the first criteria it has some claim of at least face validity on the second. What is really needed is some indication of the percentage of variance that can be reliably accounted for with these methods. Unfortunately definitive data are rare to non-existent, although impressive claims for correlations in the 0.8 to 0.9 range have been made for individual cases (e.g., Bateman and Thompson, 1986; Iavecchia, Linton, Bittner Jr., *et al*., 1989). Again the comparative assessment of models in a competitive environment should allow benchmarks to be established.

Conclusions

This document describes a time-based information processing model for the human operator, and derives various relationships and rules necessary for implementing these ideas in a task network simulation environment. The implementation of the IP/PCT model in IPME demonstrates that quite complex models can be embedded in task network environments within the limited degrees of freedom offered. This implementation covers both an allocation of attention module for scheduling tasks, and methods for predicting operator load and performance from the resulting task demand. The model that provides the framework for this report has been partially validated; however, within the context of this implementation further validation is necessary. Many of the parameters required by various elements of the implementation have been assigned arbitrarily and need to be verified.

The approach that follows from the theoretical framework offered by the IP/PCT model breaks from recent trends for workload prediction, which have been dominated by resource theory models, to focus once again on the time domain — specifically time pressure — as the prime driver of operator processing load, errors and performance. In returning to methods which appear at first glance to be similar to traditional *time occupied* models, the pitfalls inherent in these established procedures have been avoided. The framework for the implementation described in this document incorporates aspects of both serial and parallel processing, acknowledges task interference in multi-task situations, and handles both continuous and discrete tasks. Further, by returning to the time domain, model predictions are more readily testable.

This implementation of the IP/PCT model balances the more traditional focus on workload assessment with an emphasis on operator performance and error. This is achieved by tracking the tasks serviced by the allocation of attention module and logging and categorising the tasks shed, interrupted or postponed. This change of focus seems reasonable for competitive military systems, where the reduction of operator workload is probably not an achievable goal. For such systems, the aim of the designer should be to maximise overall system performance for a given level (generally maximal) of expended operator information processing capacity.

This page intentionally left blank.

References

Aldrich, T. B., Craddock, W., and McCracken, J. H. (1984). A computer analysis to predict crew workload during LHX scout-attack missions: Volume 1 (MDA903-81-C-0504/ASI479-054-I-84(B)). Fort Rucker, AL, USA: United States Army Research Institute Field Unit.

Allen, R. W., McRuer, D. T., and Thompson, P. M. (1989). Dynamic systems analysis programs with classical and optimal control applications of human performance models. In, G. R. McMillan, D. Beevis, E. Salas, M. H. Strub, R. Sutton and L. van Breda (Eds.), *Applications of Human Performance Models to Systems Design*. New York, NY, USA: Plenum Press. 169-184.

Bateman, R. P., and Thompson, M. W. (1986). Correlation of predicted workload with actual workload measured using the Subjective Workload Assessment Technique (SAE AeroTech). Warrendale, PA, USA: Society of Automotive Engineers.

Campbell, E. L. (1989). The application of queuing theory to the modelling of CP-140 aircraft communications (DCIEM No. 89-TR-23). North York, Ontario, Canada: Defence and Civil Institute of Environmental Medicine.

Card, S. K., Moran, T. P., and Newell, A. (1983). *The Psychology of Human-Computer Interaction*. Hillsdale, New Jersey, USA: Lawrence Erlbaum Associates.

Checkland, P. (1981). *Systems Thinking, Systems Practice*. New York, NY, USA: John Wiley and Sons.

CMC (1992). Aurora Update evaluation: concluding report (DSS Contract No. W8477-9-AC33/01-QF for DND, Ottawa, Canada). Kanata, Ontario, Canada: Canadian Marconi Company.

CMC (1994). System Operator Loading Evaluation: Methodology documentation (SSC Contract W7711-2-7160/01/XSE for DND, Ottawa, Canada). Kanata, Ontario, Canada: Canadian Marconi Company.

Cumming, R. W., and Croft, P. G. (1973). Human information processing under varying task demand. *Ergonomics*, 16(5), 581-586.

Davis, M. (1971). Application of fast-time simulation techniques to the study of ATC systems. *Ergonomics*, 14(1), 661-668.

Detweiler, M., and Schneider, W. (1991). Modeling the acquisition of dual-task skill in a connectionist/control architecture. In, D. L. Damos (Ed.), *Multiple-task Performance*. London, United Kingdom: Taylor and Francis Ltd. 69-99.

Doering, B., and Berheide, W. (1981). A review of simulation languages and their application to manned systems design. In, J. Moraal and K. F. Kraiss (Eds.), *Manned Systems Design: Methods, Equipment, and Applications*. New York, NY, USA: Plenum Press.

East, K. P. (1993). *Operator performance following overload: Is 'Hysteresis' a factor in complex cognitive tasks*. Unpublished Honours Thesis. Waterloo, Ontario: Wilfrid Laurier University.

East, K. P. (1996). Workload, performance and the development of situational awareness: An information processing approach (Thesis, Master of Arts). Guelph, Ontario, Canada: Depatment of Psychology, University of Guelph.

Endsley, M. R. (1993). Situation awareness in dynamic decision making: Theory. In, *Proceedings of the 1st International Conference on Situational Awareness in Complex Systems*.

Farrell, P. S. E., and Hendy, K. C. (1993). Analysis of the hysteresis effect: Short term memory hypothesis. In, *Proceedings of the Human Factors Association of Canada's 26th Annual Conference*. Mississauga, Ontario, Canada: Human Factors Association of Canada. 73-78.

Glenn, F., Cohen, D., Wherry Jr., R., and Carmody, M. (1994). Development and validation of a workload assessment technique for cockpit function allocation. In, K. C. Hendy (Ed.), *Proceedings of the 'Workshop on Task Network Simulation for Human-Machine System Design'*. Washington, DC, USA: The Technical Cooperation Program, Subgroup U, Technical Panel 7. 59-88.

Hawkins, H. L., Olbrich-Rodriguez, E., Halloran, T. O., Ketcum, R. D., Bachmann, D. B., and Reicher, G. M. (1979). Preparation cost and dual task performance: further evidence against a general time sharing factor (Contract No. N14-77-C-643). Arlington, VA, USA: Personnel and Training Research Program, Office of Naval Research.

Hendy, K. C. (1994a). Implementation of a human information processing model for task network simulation (DCIEM No 94-40). North York, Ontario, Canada: Defence and Civil Institute of Environmental Medicine.

Hendy, K. C. (1994b). An information processing model for workload and performance prediction. In, K. C. Hendy (Ed.), *Proceedings of the 'Workshop on Task Network Simulation for Human-Machine System Design'*. Washington, DC, USA: The Technical Cooperation Program, Subgroup U, Technical Panel 7. 25-45.

Hendy, K. C. (1994c). Survey of national practices in task network simulation for human machine systems. Washington, DC, USA: The Technical Cooperation Program, Subgroup U, Technical Panel 7.

Hendy, K. C. (1995). Situation awareness and workload: Birds of a feather? In, *Proceedings (CP-575) of the AGARD AMP Symposium on 'Situation Awareness: Limitations and Enhancement in the Aviation Environment'*. Neuilly-sur-Seine, France: Advisory Group for Aerospace Research and Development. 21-1 to 21-7.

Hendy, K. C., Beevis, D., Lichacz, F., and Edwards, J. L. (2002). Analyzing the cognitive system from a perceptual control theory point of view. In, M. D. McNeese and M. A. Vidulich (Eds.), *Cognitive Systems Engineering in Military Aviation Environments: Avoiding Cogminutia Fragmentosa!* Wright Patterson AFB, Dayton, OH, USA: Human Systems Information Analysis Center. 201-250.

Hendy, K. C., Kobierski, R. D., and Youngson, G. A. (1992). The integration of human factors engineering analyses with manpower and personnel studies. In, *Technical Proceedings AC/243(Panel 8)TP/5 — Workshop on Liveware Integration Needs*. Brussels, Belgium: NATO Defence Research Group, Research Study Group 21, Panel 8. 8-1 to 8-11.

Hendy, K. C., Liao, J., and Milgram, P. (1997). Combining time and intensity effects in assessing operator information processing load. *Human Factors*, 39(1), 30-47.

Hicks, M. (1993). AWAS (Aircrew Workload Assessment System) analytical workload modelling tool — research and development programme. In, *Proceedings of the RAS Conference on 'Workload Assessment and Aviation Safety'*. London, United Kingdom: Royal Aeronautical Society. 4.1-4.8.

Hillier, F. S., and Lieberman, G. J. (1974). *Operations Research (Second Edition)*. San Francisco, CA, USA: Holden-Day, Inc.

Iavecchia, H. P., Linton, P. M., Bittner Jr., A. C., and Byers, J. C. (1989). Operator workload in the UH-60A Black Hawk: crew results vs. TAWL model predictions. In, *Proceedings of the Human Factors Society's 33rd Annual Meeting*. Santa Monica, CA, USA: Human Factors Society. 1481-1485.

Jensen, S. (1994). Scenario profiling — using task network simulations of task analysis and workload as the backbone for integrated human factors studies. In, K. C. Hendy (Ed.), *Proceedings of the 'Workshop on Task Network Simulation for Human-Machine System Design'*. Washington, DC, USA: The Technical Cooperation Program, Subgroup U, Technical Panel 7. 89-94.

Jex, H. R. (1988). Measuring mental workload: problems progress and promises. In, P. A. Hancock and N. Meshkati (Eds.), *Human Mental Workload*. Amsterdam, The Netherlands: Elsevier Science Publishers B.V. 5-38.

Jordan, C. S., Farmer, E. W., Belyavin, A. J., Selcon, S. J., Bunting, A. J., Shanks, C. R., and Newman, P. (1996). Empirical validation of the Prediction of Operator Performance (POP) Model. In, *Proceedings of the Human Factors and Ergonomics Society's 40th Annual Meeting*. Santa Monica, CA, USA: Human Factors and Ergonomics Society. 39-43.

Kinchla, R. A. (1980). The measurement of attention. In, R. S. Nickerson (Ed.), *Attention and Performance VIII*. Hillsdale, NJ, USA: Lawrence Erlbaum Associates, Publishers. 213-238.

Laughery, K. R., Drews, C., Archer, R., and Kramme, K. (1986). A Micro SAINT simulation analyzing operator workload in a future attack helicopter. In, *Proceedings of the IEEE National Aerospace and Electronics Conference (NAECON)*. New York, NY, USA: Institution of Electrical and Electronic Engineers. 896-903.

Linton, P. M., Jahns, D. W., and Chatelier, P. R. (1977). Operator workload assessment model: an evaluation of a VF/VA-V/STOL system. In, *Proceedings of the AGARD Conference on 'Methods to Assess Workload' (AGARD-CPP-216)*. Neuilly-sur-Seine, France: Advisory Group for Aerospace Research and Development. A12-1 to A12-11.

Linton, P. M., Plamondon, B. D., Dick, A. O., Bittner Jr., A. C., and Christ, R. E. (1989). Operator workload for military system acquisition. In, G. R. McMillan, D. Beevis, E. Salas, M. H. Strub, R. Sutton and L. van Breda (Eds.), *Application of Human Performance Models to System Design*. New York, NY, USA: Plenum Press. 21-45.

Little, R., Dahl, S., Plott, B., Wickens, C., Powers, J., Tillman, B., Davilla, D., and Hutchins, C. (1993). Crew Reduction in Armoured Vehicles Ergonomic Study (CRAVES) (ARL-CR-80). Aberdeen Proving Ground, MD, USA: US Army Research Laboratory, Human Research and Engineering Directorate.

Malone, T. B., Kirkpatrick, M., and Kopp, W. H. (1986). Human factors engineering impact of system workload and manning levels. In, *Proceedings of the Human Factors*

Society's 30th Annual Meeting. Santa Monica, CA, USA: Human Factors Society. 763-767.

Mancini, G. (1988). Modelling humans and machines. In, L. P. Goodstein, H. B. Andersen and S. E. Olsen (Eds.), *Tasks, Errors and Mental Models*. London, United Kingdom: Taylor and Francis. 278-292.

Meister, D. (1985). *Behavioral Analysis and Measurement Methods*. New York, NY, USA: John Wiley and Sons.

MicroAnalysis (1987). *Micro SAINT: user's guide*. Boulder, CO, USA: Micro Analysis and Design, Inc.

MIL-STD-46855 (1994). *Human Engineering Requirements for Military Systems, Equipment and Facilities*. Washington, DC, USA: Department of Defense.

Miller, G. A. (1971). What is information measurement? In, W. C. Howell and I. L. Goldstein (Eds.), *Engineering Psychology - Current Perspectives in Research*. New York, NY, USA: Appleton-Century-Crofts. 132-142.

Moray, N. (1986). Monitoring behavior and supervisory control. In, K. R. Boff, L. Kaufman and J. P. Thomas (Eds.), *Handbook of Perception and Performance: Volume II, Cognitive Processes and Performance*. New York, NY, USA: John Wiley and Sons. 40-1 to 40-51.

North, R. A., and Riley, V. A. (1989). W/INDEX: A predictive model of operator workload. In, G. R. McMillan, D. Beevis, E. Salas, M. H. Strub, R. Sutton and L. van Breda (Eds.), *Applications of Human Performance Models to Systems Design*. New York, NY, USA: Plenum Press. 81-89.

Parks, D. L., and Boucek Jr., G. P. (1989). Workload prediction, diagnosis, and continuing challenges. In, G. R. McMillan, D. Beevis, E. Salas, M. H. Strub, R. Sutton and L. van Breda (Eds.), *Applications of Human Performance Models to Systems Design*. New York, NY, USA: Plenum Press.

Powers, W. T. (1973). Feedback: beyond behaviorism. *Science*, 179(4071), 351-356.

Powers, W. T. (1989). An outline of control theory. In, R. S. Marken (Ed.), *Living Control Systems — Selected Papers of William T. Powers*. Gravel Switch, Kentucky, USA: The Control Systems Group, Inc. 253-293.

Rasmussen, J. (1983). Skills, rules and knowledge; signals, signs and symbols and other distinctions in human performance models. *IEEE Transactions on Systems, Man and Cybernetics*, SMC-13(3), 257-266.

Riley, V., Lyall, E., Cooper, B., and Weiner, E. (1991). Analytic methods for flight deck automation design and evaluation, Phase One Report: Flight crew workload prediction (FAA Contract Number DTFA01-91-C-00039). Minneapolis, MN, USA: Honeywell Technology Center.

Seifert, R. (1980). Man-machine system performance as a function of the system demand/workload relationship. In, J. Moraal and K.-F. Kraiss (Eds.), *Pre-prints of the Proceedings of the Conference on Manned Systems Design*. NATO. 160-180.

Seigel, A. I., and Wolf, J. J. (1969). *Man-machine Simulation Models*. New York, NY, USA: John Wiley and Sons, Inc.

Shaffer, M. T., Hendy, K. C., and White, L. R. (1988). An empirically validated task analysis (EVTA) of low level army helicopter operations. In, *Proceedings of the Human*

Factors Society's 32nd Annual Meeting. Santa Monica, CA, USA: Human Factors Society. 178-182.

Smolensky, M. W. (1990). *The effect of work load history on operational errors in air traffic control simulation: the hysteresis effect — expectancy perseverance or short-term-memory overload?* Unpublished PhD Thesis. Texas, USA: Texas Technical University.

Sperandio, J.-C. (1978). The regulation of working methods as a function of workload among air traffic controllers. *Ergonomics*, 21(3), 195-202.

Thompson, M. M., and Jamieson, D. W. (1995). ATG/DCIEM human factors study of the CC-130: Recommendations for mental model assessment (SSC Contract W7711-4-7238 — Draft Report). Toronto, ON, Canada: Thompson Lightstone and Company Limited.

Van de Vegte, J. (1986). *Feedback Control Systems*. Englewood Cliffs, NJ, USA: Prentice-Hall Inc.

Wickens, C. D. (1992). *Engineering Psychology and Human Performance* (Second Edition). New York, NY, USA: Harper Collins Publishers Inc.

Wingert, J. W. (1973). Function interlace modifications to analytic workload prediction. In, K. Cross and J. McGrath (Eds.), *Crewstation Design: An Interagency Conference*. Santa Barbara, CA, USA: Anacapa Sciences. 373-378.

Wolfram, S. (1991). *Mathematica: A System for Doing Mathematics by Computer* (Second Edition). Redwood City, CA, USA: Addison-Wesley Publishing Company, Inc.

Woodson, W. E. (1981). *Human Factors Design Handbook*. New York, NY: McGraw-Hill Book Company.

Wortman, D. B., Duket, S. D., Seifert, D. J., Hann, R. L., and Chubb, G. P. (1978). The SAINT user's manual (AMRL-TR-77-62). Wright-Patterson Air Force Base, Dayton, OH, USA: United States Air Force Aerospace Medical Research Laboratories.

This page intentionally left blank.

List of symbols/abbreviations/acronyms/initialisms

DND	Department of National Defence

Distribution list

[Enter distribution list here if applicable. If not, delete entire section.]

ANNEX D

OPERATIONAL SEQUENCE DIAGRAMS

14 June 2004

ANNEX D
OPERATIONAL SEQUENCE DIAGRAMS

D.1 GENERAL

Basic information describing the nature of the Operational Sequence Diagrams and the meaning of the various symbols used in the diagrams is presented herein.

D.2 INTERPRETATION OF OPERATIONAL SEQUENCE DIAGRAMS

The network model consists of a series of OSDs which graphically illustrate the logical interconnection of tasks and the flow of information throughout the system during the conduct of the composite scenario. OSDs are critical to an effective HFE program in that they support a wide range of activities during the three phases of equipment procurement (i.e. analysis, design and development, and test and evaluation). OSDs are prepared in accordance with the guidelines in MIL-HDBK-46855. They are particularly useful for the analysis of highly complex systems which require many time-critical information-decision-action functions by multiple users. By using symbology to indicate actions, inspections, data manipulation (i.e. transmission, reception and storage), time delays and decisions, OSDs show the flow of information and operator functions through the system in relation to the mission timeline. Special symbols have been incorporated into the OSDs to provide the additional information necessary for the translation to a probabilistic model. A review of the symbols used is presented in Figure D.1.

The pages of the OSDs should be viewed sequentially, with the flow of events and tasks being from the top of the sheet towards the bottom. The title at the top of the page represents the part of the composite scenario in which the flight segments occur. Individual tasks are identified by task labels and by the top-down HGA task identification number, both listed beside the task symbol. The numbers inside the symbols refer to the tasks listed in the bottom-up HGA. The number in parentheses, e.g. (... 120) represents the next higher goal which an operator is attempting to achieve. These higher goals are represented graphically in one of the three columns of the OSD entitled "Upper Level Goals".

The layout and graphic symbology used in OSDs generally follow the conventions laid out in the Military Handbook. A number of additional graphic elements have been added to the OSD format to improve readability and convey the additional network information available from the network database. The following subparagraphs provide a brief summary of the OSD formats used for the analysis:

a. **Continuous Task Symbols.** Continuous task symbols are used to indicate an ongoing task which starts either at the beginning of the segment or upon completion of another task. Continuous tasks are indicated by a vertical arrow pointing down from the centre of the symbol. Operations and inspection tasks may be performed on a continuous basis. Examples of continuous tasks are monitoring VTUAV systems and fuel flow or monitoring progress toward a waypoint.

b. **Flow Loopback Symbols.** Tasks to be performed repeatedly (e.g. repeated searches with a UAV EO suite) are represented by means of an arrow from the last task in the sequence back to the task which starts the sequence. In order to enhance the readability of the complex task relationships, the return symbol has been truncated to a short loopback arrow supplemented with a text label indicating the destination task of the loopback.

c. **Elapsed Time and Temporal Displacement.** OSD symbology is presented against a time scale which runs vertically from top to bottom. Time elapsed during the performance of a task is represented by the vertical spacing between successive tasks (i.e. equivalent to the task completion time). The time scale on OSDs is not necessarily continuous (partially to conserve paper when few activities are occurring), but task interrelationships are accurate. For example, tasks performed simultaneously are drawn beside each other, space permitting. If a task starts chronologically after another has been completed, regardless of whether they are related or not, it is drawn on a lower line (row) than the first task. In this way, the logical and time-oriented flow of tasks is maintained. Time is recorded in minutes and seconds and is based on the elapse time of the segment part.

d. **Timer Symbols.** In order to represent time gaps between successive task elements, a timer is used (represented by a small analogue clock face). Where one task logically follows another task after a fixed or variable time delay, the timer symbol is drawn between the respective task symbols. Timers may also have a variable time associated with them to reflect the randomness of the real world.

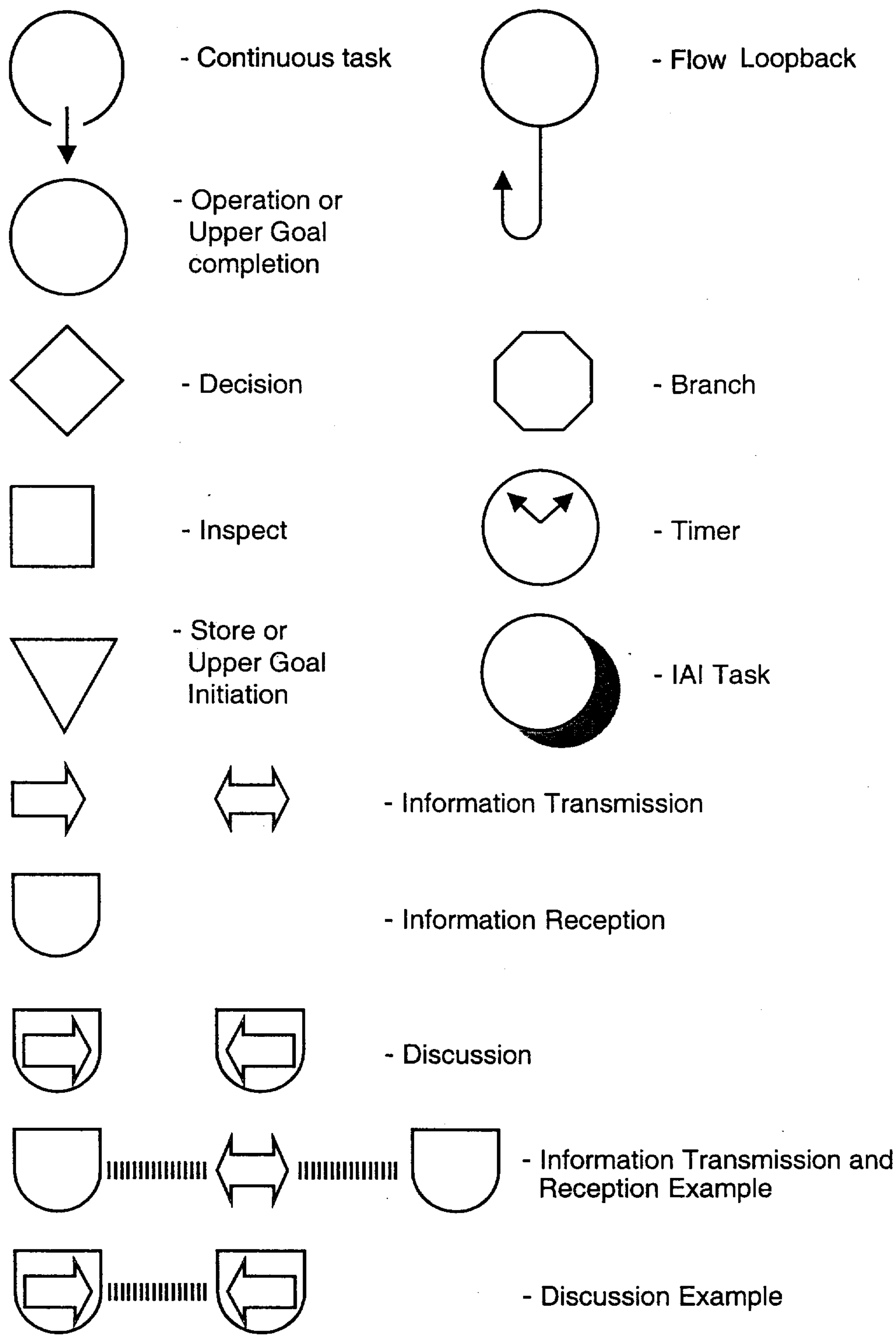


Figure D-1 Operational Sequence Diagram Symbology

The following OSD represents in graphical form Part One of the Composite Scenario, which is shown in Figure D-2. The timing shown on this figure represents the occurrence of events from the scenario; however the OSDs contain a temporal relationship based on the task network and the times included there will not necessarily match the storyline of this figure.

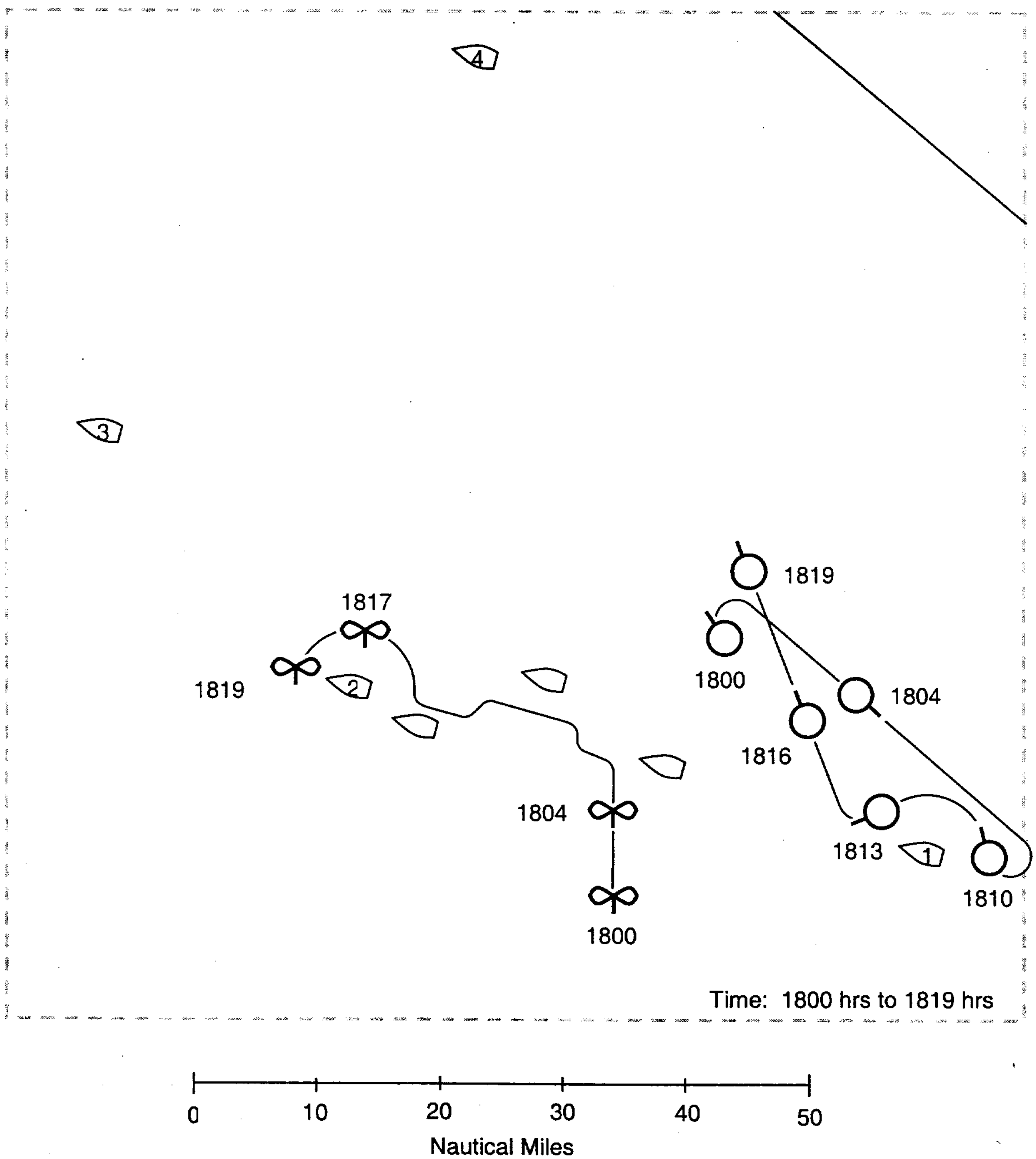


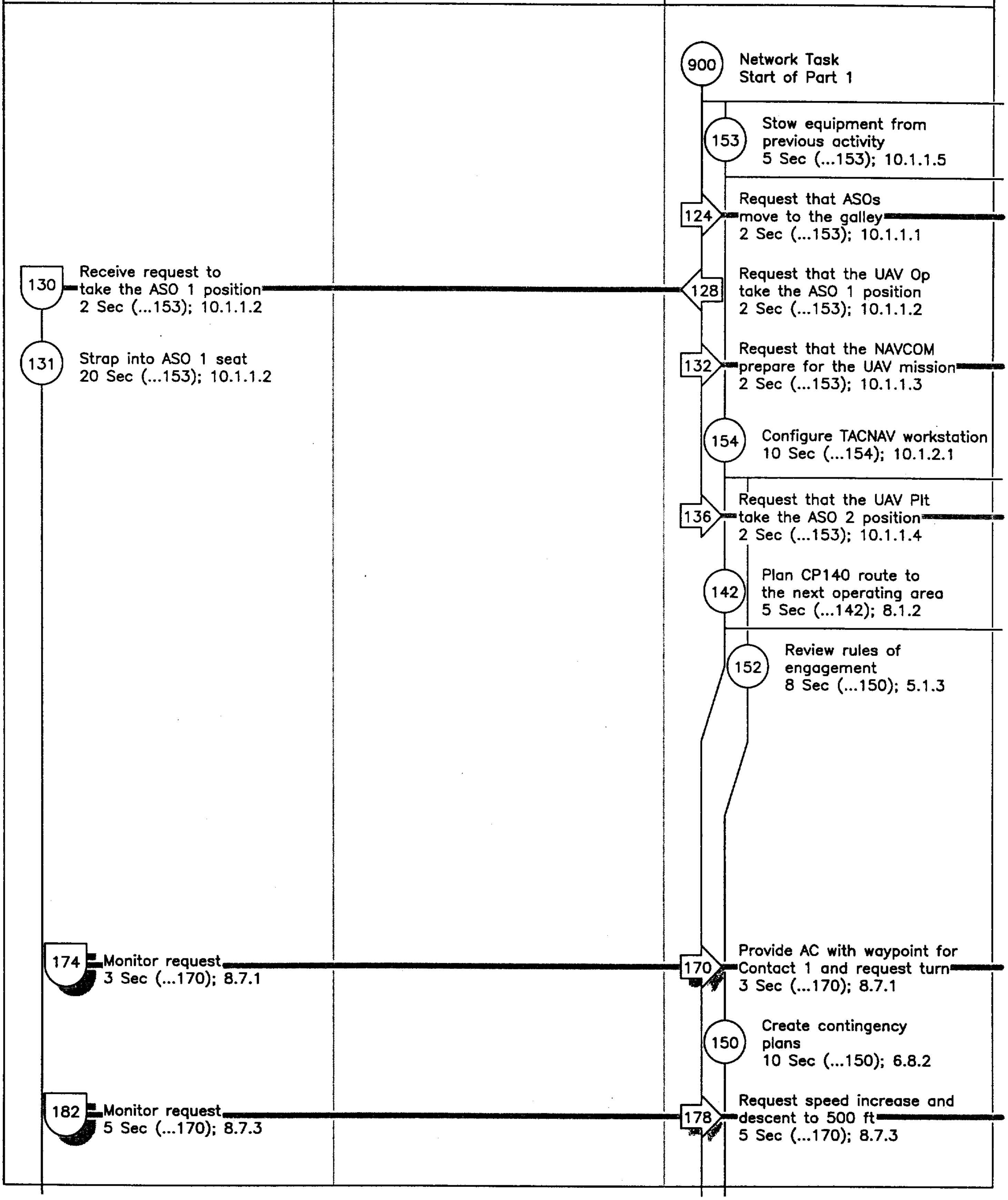
Figure D-2 Detailed Mission Scenario – Part 1

Part 1 Min 1–20	IP/PCT Scenario of UAV Operations Control of Single VTUAV During Search for Terrorist Vessel		Page 1
Time Min/Sec	Other Units: ROC, CPF	Mini UAVs	VTUAV
0 0			
0 0			
0 2			
0 4			
0 5			
0 6			
0 12			
0 15			
0 15			
0 20			
0 20			
0 20			
0 22			
0 23			

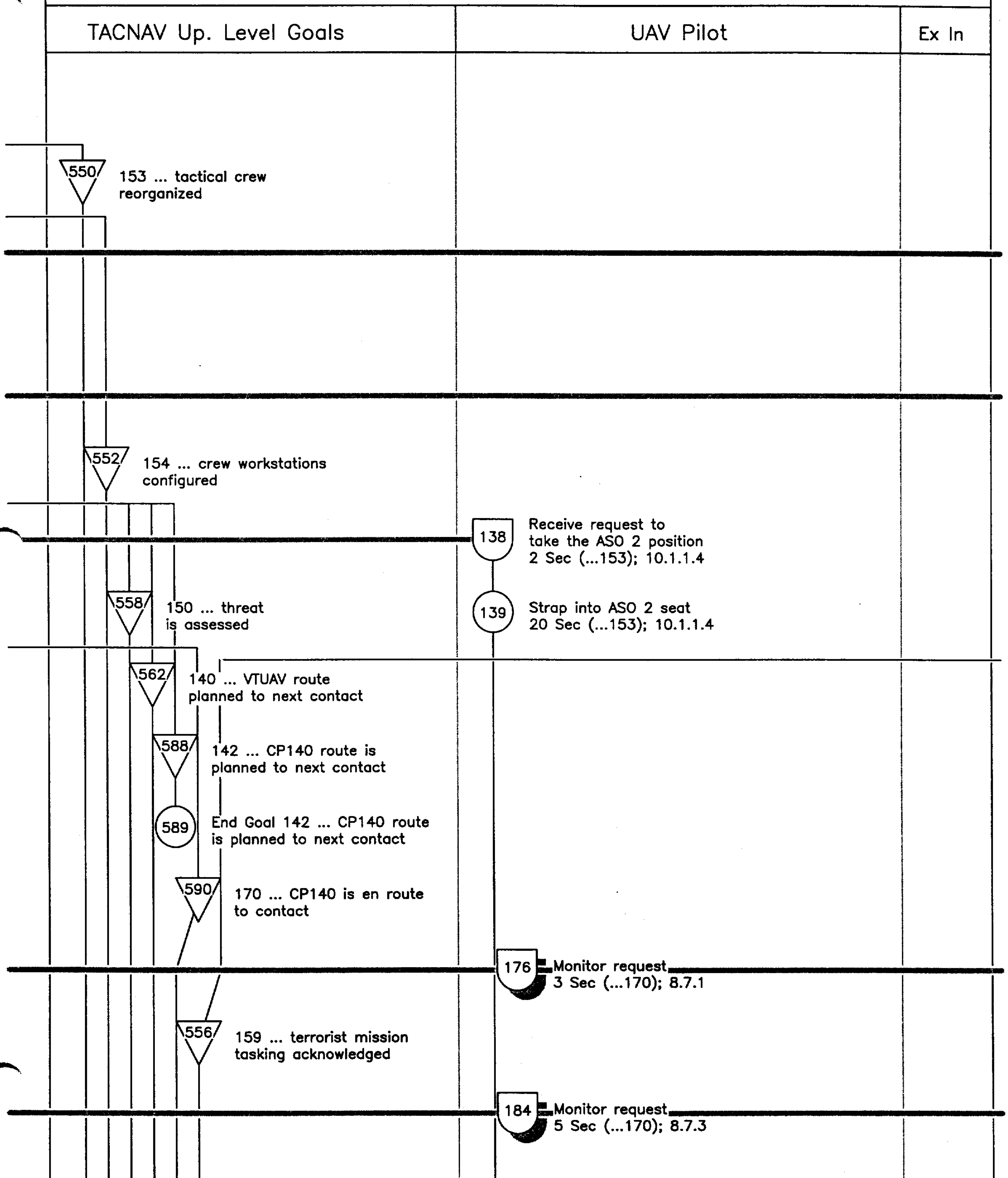
Time and Date of Data File: 15.00 10 Jun 04

Part 1 IP/PCT Scenario of UAV Operations Page 2
Min 1–20 Control of Single VTUAV During Search for Terrorist Vessel

UAV Operator	UAV Op Up. Level Goals	TACNAV



Part 1 IP/PCT Scenario of UAV Operations Page 3
Min 1–20 Control of Single VTUAV During Search for Terrorist Vessel

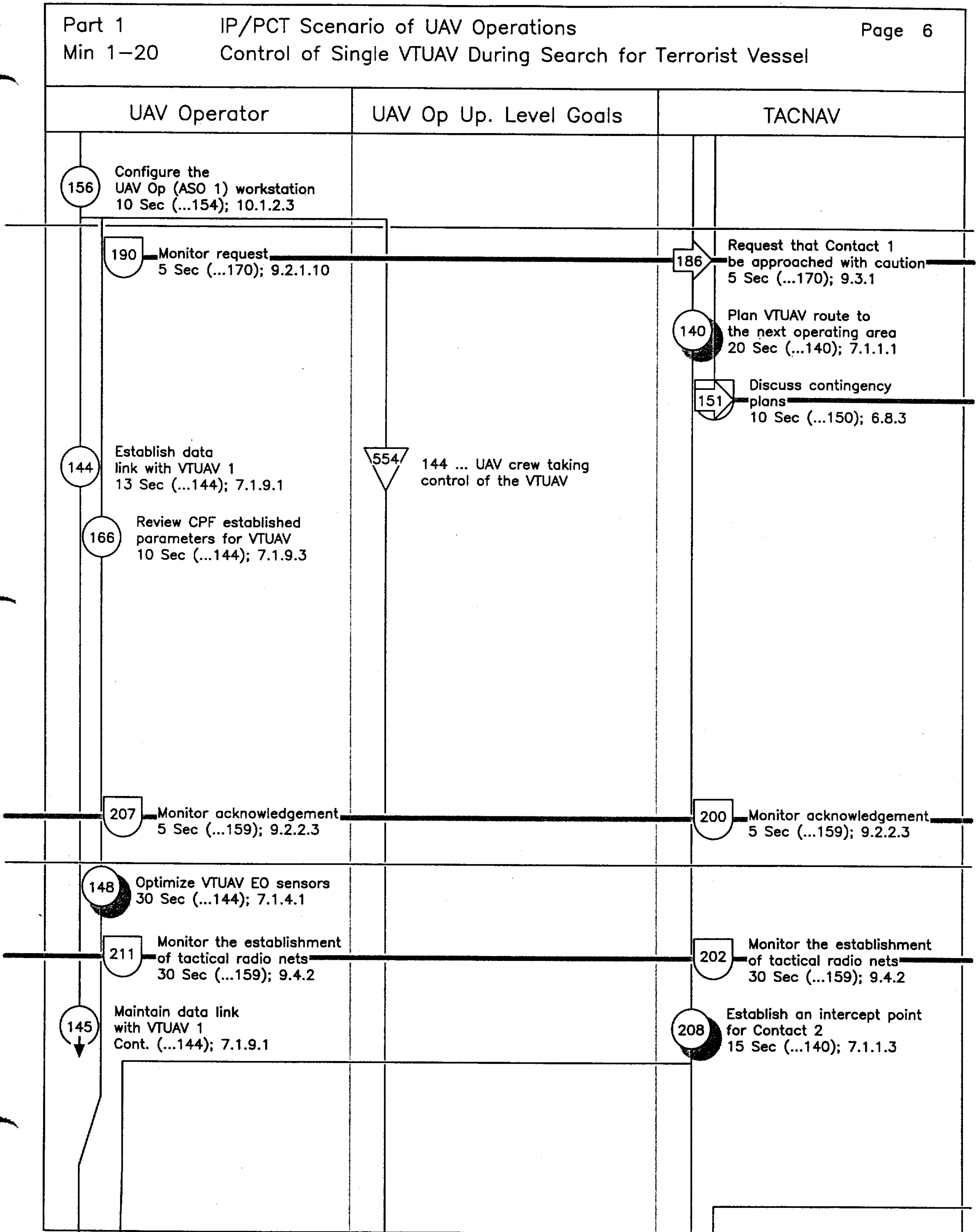


Part 1 IP/PCT Scenario of UAV Operations Page 4
Min 1–20 Control of Single VTUAV During Search for Terrorist Vessel

Ex Out	UAV Plt Up. Level Goals	Other Members of CP–140 Crew	Time Min/Sec
			0 0
		126 (ASO 1 & 2) Receive request (...153)	0 0
			0 2
		134 (NAVCOM) Receive request (...153)	0 4
		135 Stow equipment from previous activity 5 Sec (...153); 10.1.1.3	0 5
			0 6
		158 (NAVCOM) Configure the NAVCOM workstation 10 Sec (...154)	0 12
			0 15
			0 15
			0 20
			0 20
		172 (AC) Receive request 3 Sec (...170)	0 20
		159 (NAVCOM) Review tasking (...159)	0 22
		180 (AC) Receive request 5 Sec (...170)	0 23

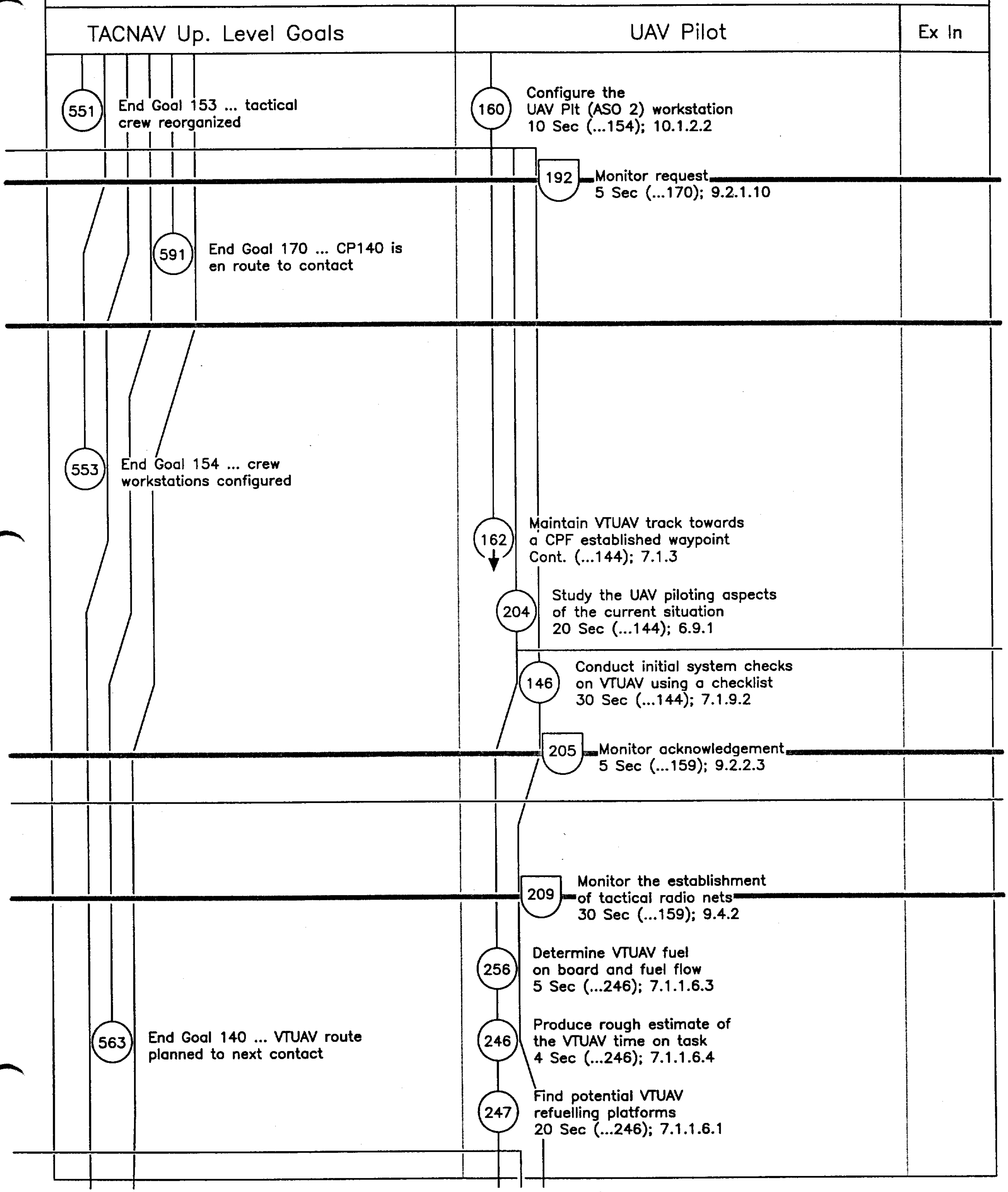
Part 1 IP/PCT Scenario of UAV Operations Page 5
Min 1–20 Control of Single VTUAV During Search for Terrorist Vessel

Time Min/Sec	Other Units: ROC, CPF	Mini UAVs	VTUAV
0 27			
0 28			
0 33			
0 33			
0 34			
0 36			
0 38			710 Maintain track towards a CPF established waypoint
0 38			
0 38			
0 41	201 (Tasking Agency) Receive tasking acknowledgement 5 Sec (...159)		
0 44			
0 46	213 Establish tactical radio nets with the CP–140 30 Sec (...159); 9.4.2		
0 54			
1 3			
1 7			


Part 1
Min 1–20
IP/PCT Scenario of UAV Operations
Control of Single VTUAV During Search for Terrorist Vessel
Page 6
UAV Operator
UAV Op Up. Level Goals
TACNAV
156
Configure the UAV Op (ASO 1) workstation
10 Sec (...154); 10.1.2.3
190
Monitor request
5 Sec (...170); 9.2.1.10
186
Request that Contact 1 be approached with caution
5 Sec (...170); 9.3.1
140
Plan VTUAV route to the next operating area
20 Sec (...140); 7.1.1.1
151
Discuss contingency plans
10 Sec (...150); 6.8.3
144
Establish data link with VTUAV 1
13 Sec (...144); 7.1.9.1
554
144 ... UAV crew taking control of the VTUAV
166
Review CPF established parameters for VTUAV
10 Sec (...144); 7.1.9.3
207
Monitor acknowledgement
5 Sec (...159); 9.2.2.3
200
Monitor acknowledgement
5 Sec (...159); 9.2.2.3
148
Optimize VTUAV EO sensors
30 Sec (...144); 7.1.4.1
211
Monitor the establishment of tactical radio nets
30 Sec (...159); 9.4.2
202
Monitor the establishment of tactical radio nets
30 Sec (...159); 9.4.2
145
Maintain data link with VTUAV 1
Cont. (...144); 7.1.9.1
208
Establish an intercept point for Contact 2
15 Sec (...140); 7.1.1.3

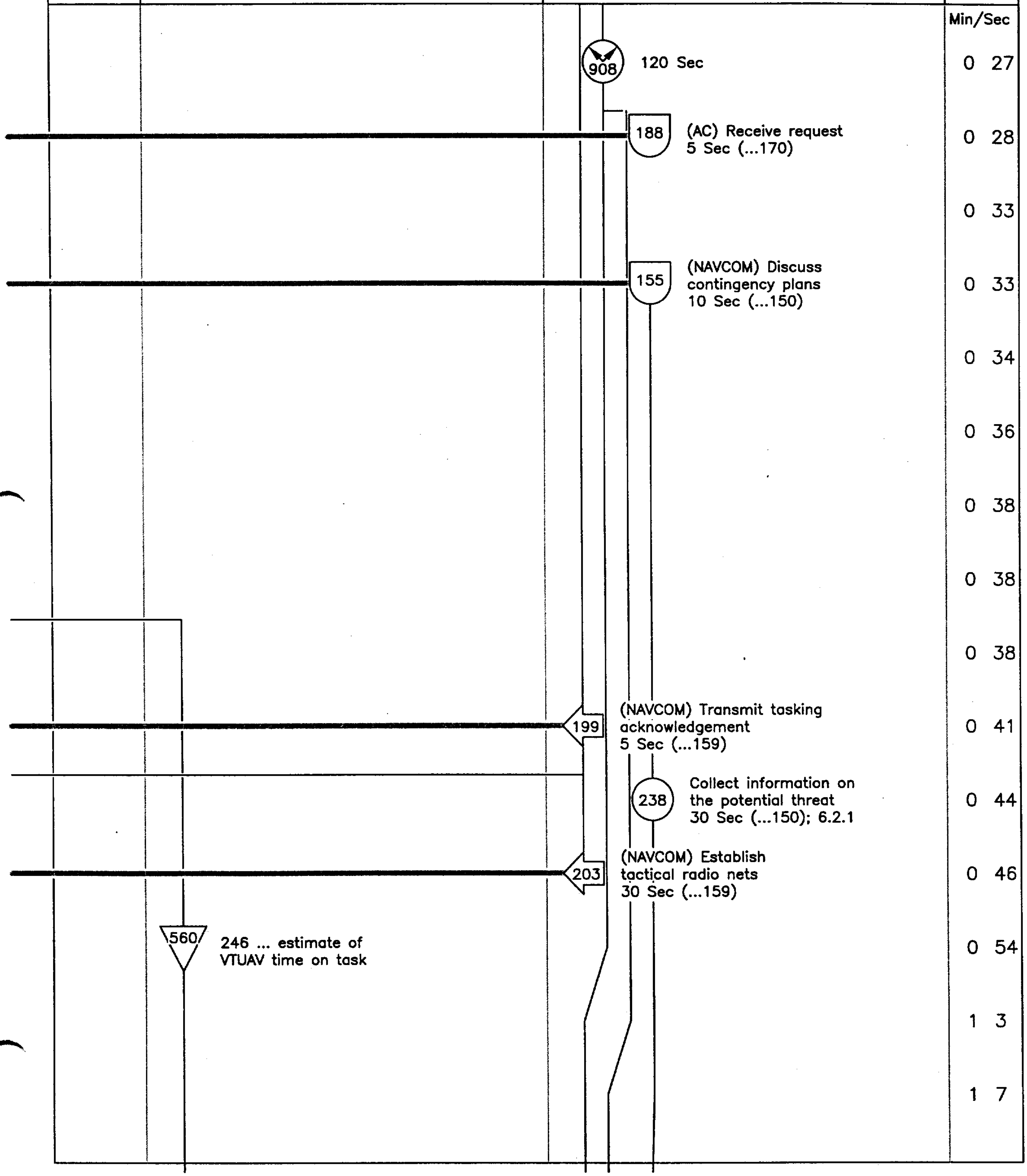
Part 1 IP/PCT Scenario of UAV Operations Page 7

Min 1–20 Control of Single VTUAV During Search for Terrorist Vessel



Part 1 IP/PCT Scenario of UAV Operations Page 8
Min 1–20 Control of Single VTUAV During Search for Terrorist Vessel

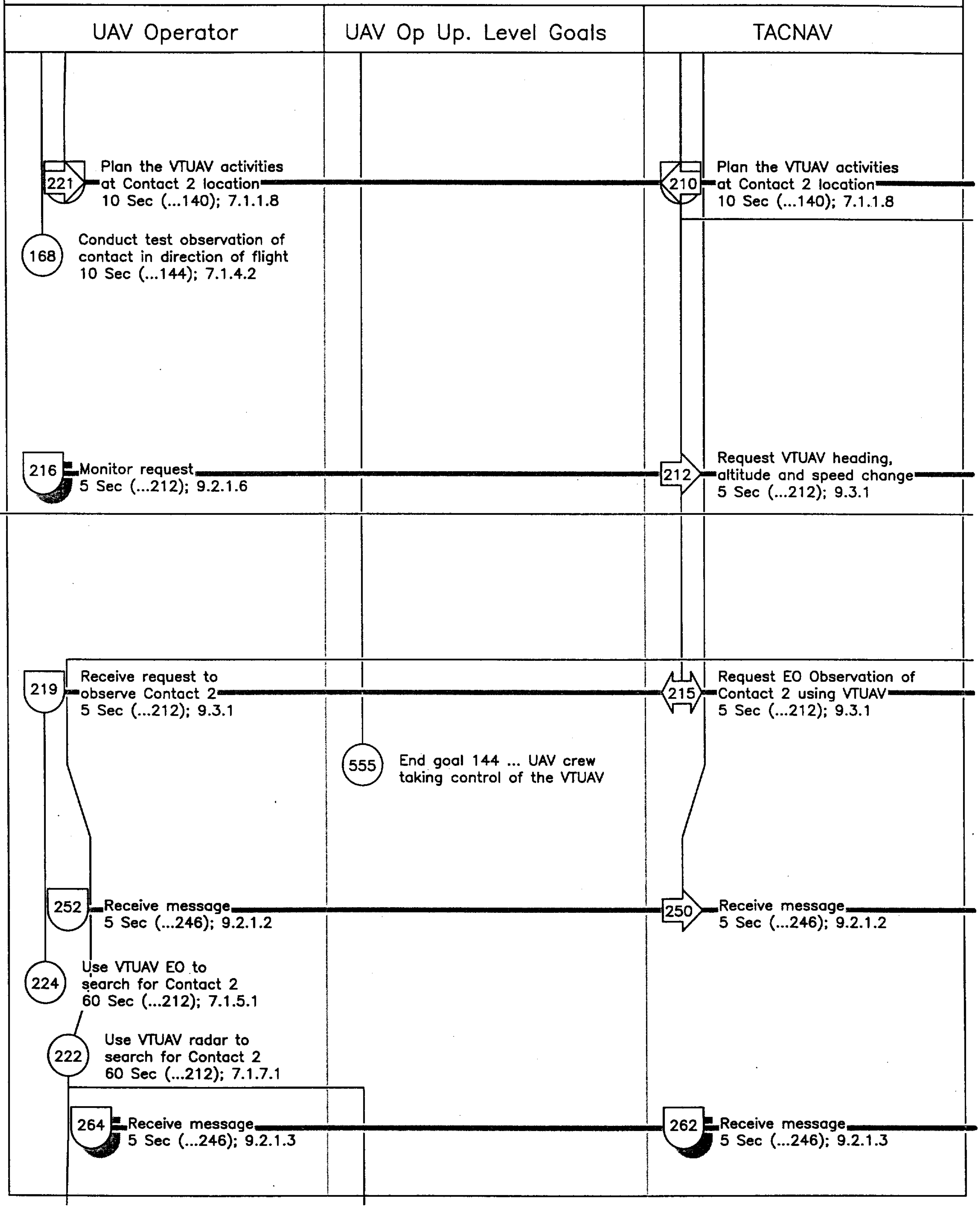
Ex Out	UAV Plt Up. Level Goals	Other Members of CP–140 Crew	Time



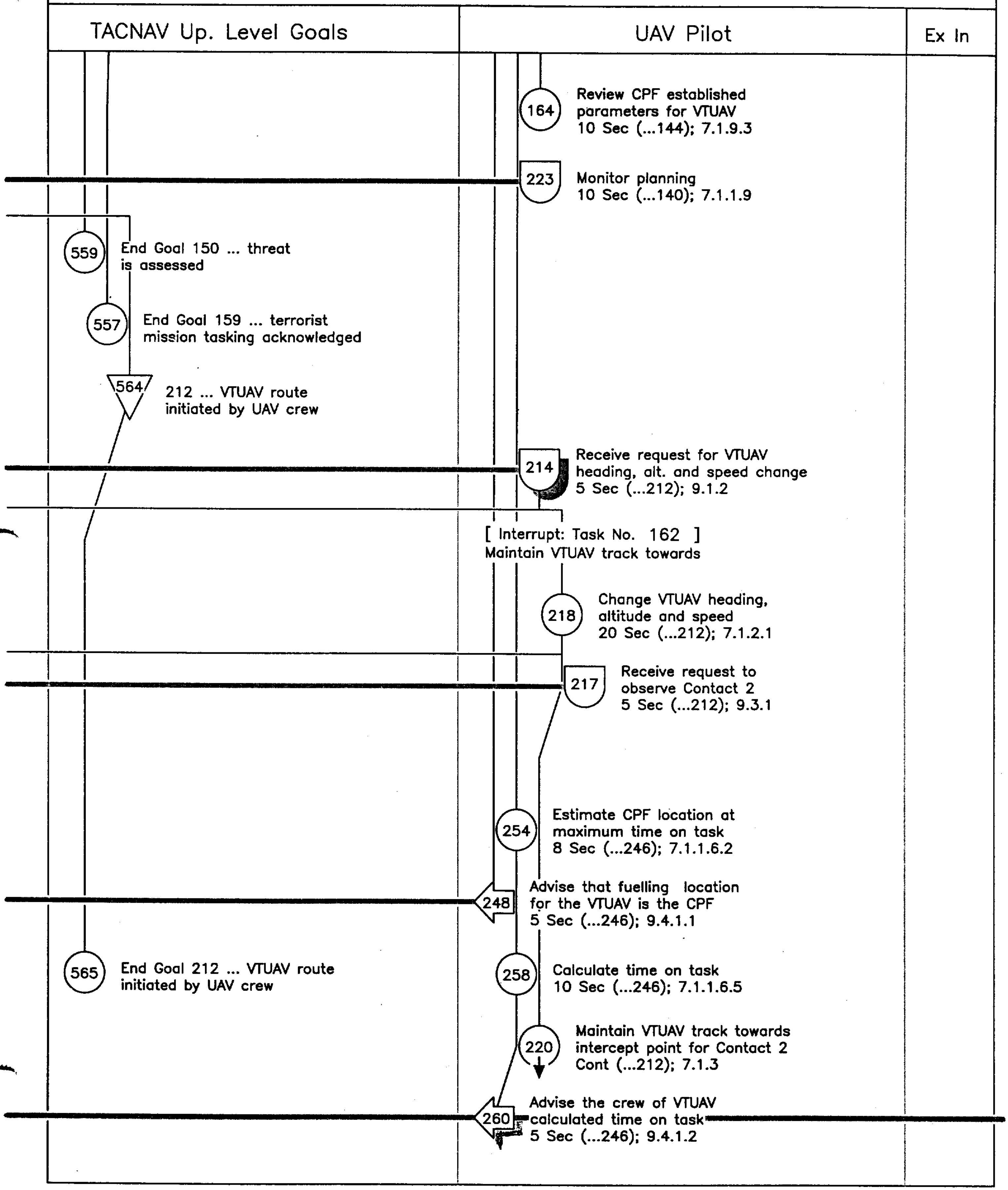
Part 1 IP/PCT Scenario of UAV Operations Page 9
Min 1–20 Control of Single VTUAV During Search for Terrorist Vessel

Time Min/Sec	Other Units: ROC, CPF	Mini UAVs	VTUAV
1 8			
1 8			
1 14			
1 16			
1 18			
1 18			
			[Interrupt: Task No. 710] Maintain track towards a
1 23			712 Change heading, altitude and speed 20 Sec
1 23			
1 24			
1 27			
1 27			
1 37			713 Maintain track towards intercept point for Contact 2
1 43			
1 45			

Part 1 IP/PCT Scenario of UAV Operations Page 10
Min 1–20 Control of Single VTUAV During Search for Terrorist Vessel



Part 1 IP/PCT Scenario of UAV Operations Page 11
Min 1–20 Control of Single VTUAV During Search for Terrorist Vessel

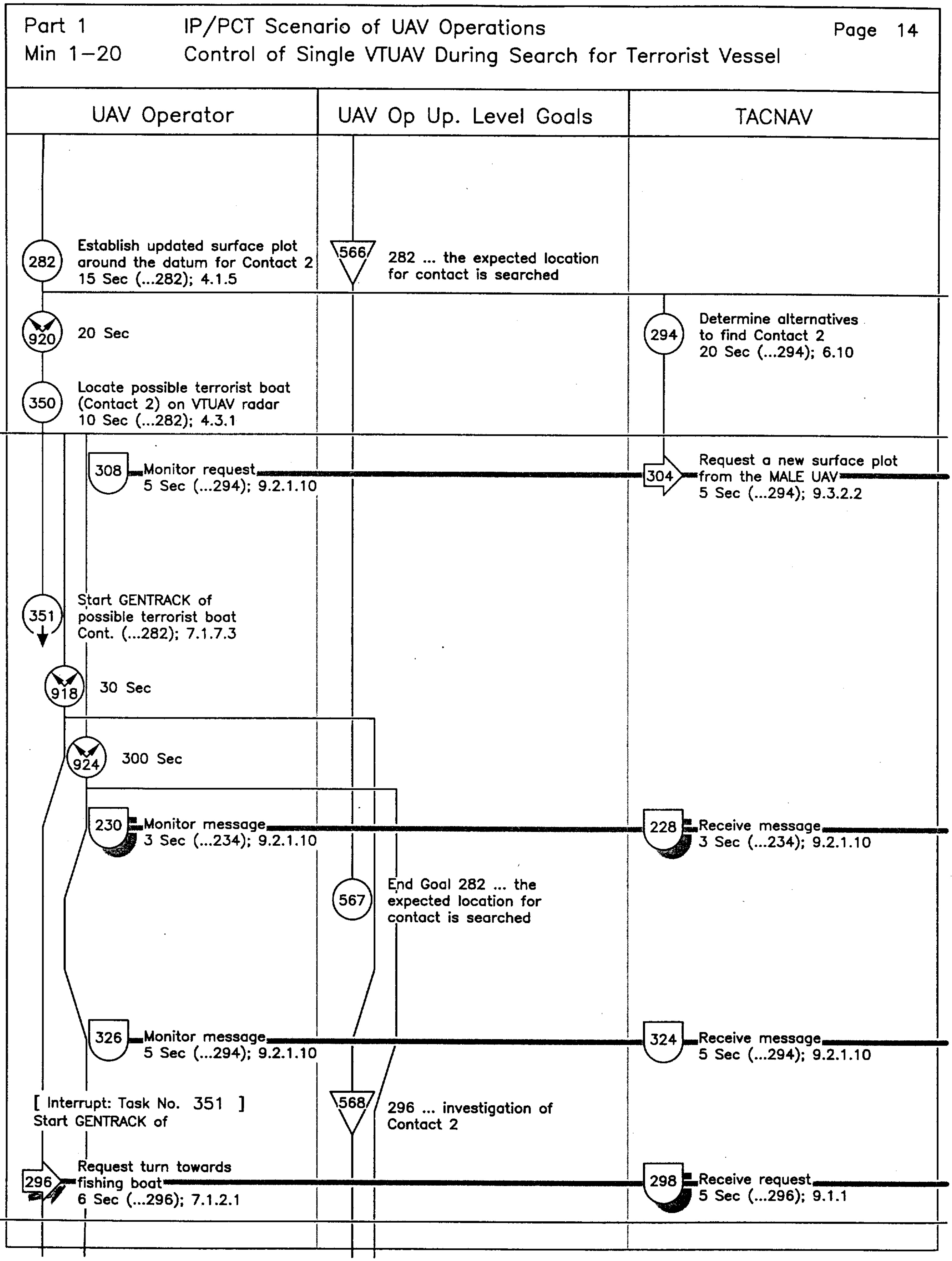


Part 1 IP/PCT Scenario of UAV Operations Page 12
Min 1–20 Control of Single VTUAV During Search for Terrorist Vessel

Ex Out	UAV Plt Up. Level Goals	Other Members of CP–140 Crew	Time Min/Sec
			1 8
			1 8
		240 Configure the CP140 countermeasures 10 Sec (...150); 10.4.3	1 14
			1 16
			1 18
			1 18
			1 23
			1 23
			1 24
			1 27
			1 27
			1 37
	561 End Goal 246 ... estimate of VTUAV time on task		1 43
		266 (Crew) Receive message 5 Sec (...246)	1 45

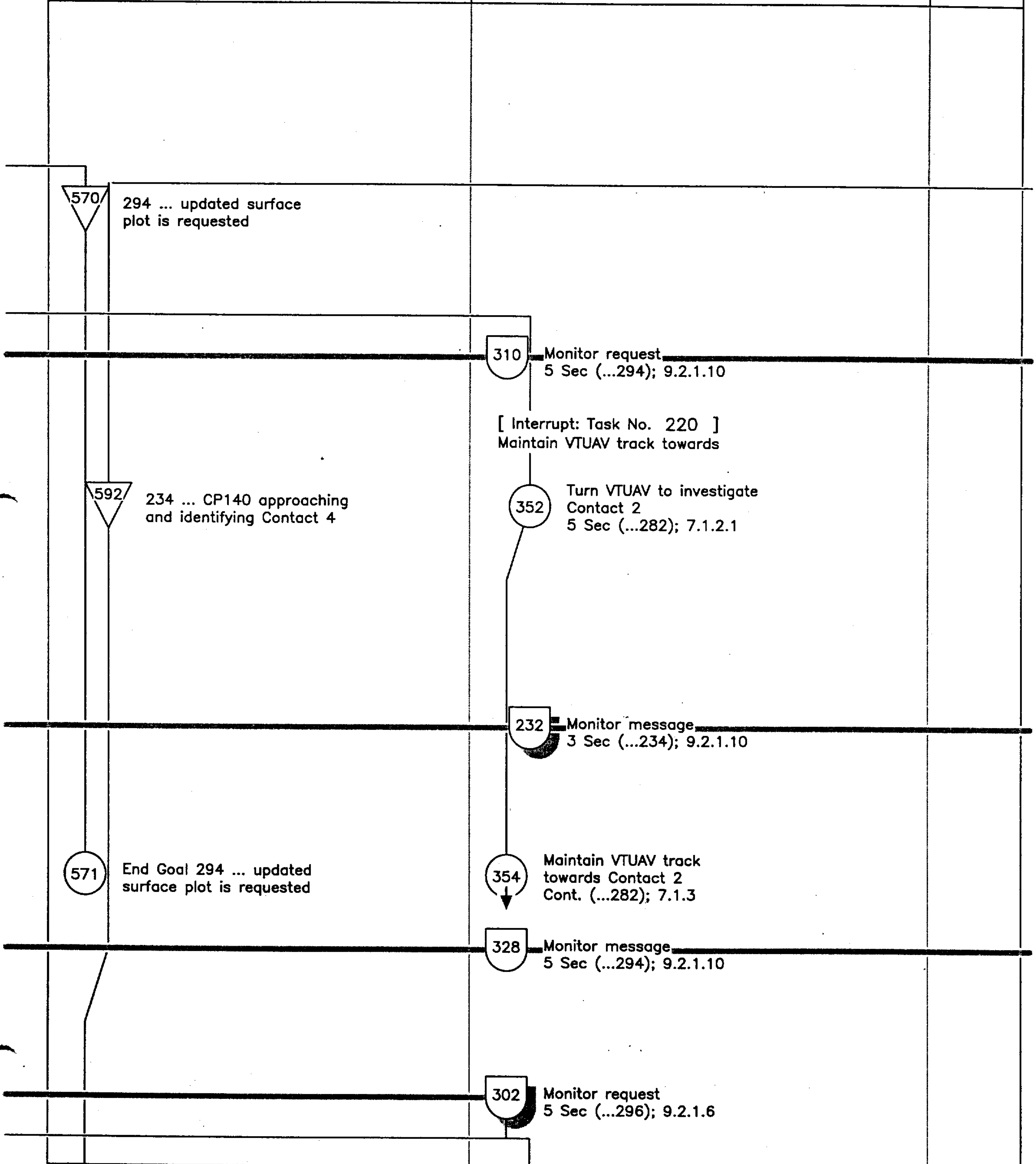
Part 1 IP/PCT Scenario of UAV Operations Page 13
Min 1–20 Control of Single VTUAV During Search for Terrorist Vessel

Time Min/Sec	Other Units: ROC, CPF	Mini UAVs	VTUAV
2 28			
2 43			
2 58			
3 18			
3 18			
			[Interrupt: Task No. 713] Maintain track towards
3 28			715 Turn to investigate Contact 2 5 Sec
3 28			
3 28			
3 31			
3 40			716 Maintain track towards Contact 2
3 53			
3 58			
3 58			


Part 1
Min 1–20
IP/PCT Scenario of UAV Operations
Control of Single VTUAV During Search for Terrorist Vessel
Page 14
UAV Operator
UAV Op Up. Level Goals
TACNAV
282
Establish updated surface plot around the datum for Contact 2
15 Sec (...282); 4.1.5
566
282 ... the expected location for contact is searched
920
20 Sec
294
Determine alternatives to find Contact 2
20 Sec (...294); 6.10
350
Locate possible terrorist boat (Contact 2) on VTUAV radar
10 Sec (...282); 4.3.1
308
Monitor request
5 Sec (...294); 9.2.1.10
304
Request a new surface plot from the MALE UAV
5 Sec (...294); 9.3.2.2
351
Start GENTRACK of possible terrorist boat
Cont. (...282); 7.1.7.3
918
30 Sec
924
300 Sec
230
Monitor message
3 Sec (...234); 9.2.1.10
228
Receive message
3 Sec (...234); 9.2.1.10
567
End Goal 282 ... the expected location for contact is searched
326
Monitor message
5 Sec (...294); 9.2.1.10
324
Receive message
5 Sec (...294); 9.2.1.10
[Interrupt: Task No. 351]
Start GENTRACK of
568
296 ... investigation of Contact 2
296
Request turn towards fishing boat
6 Sec (...296); 7.1.2.1
298
Receive request
5 Sec (...296); 9.1.1

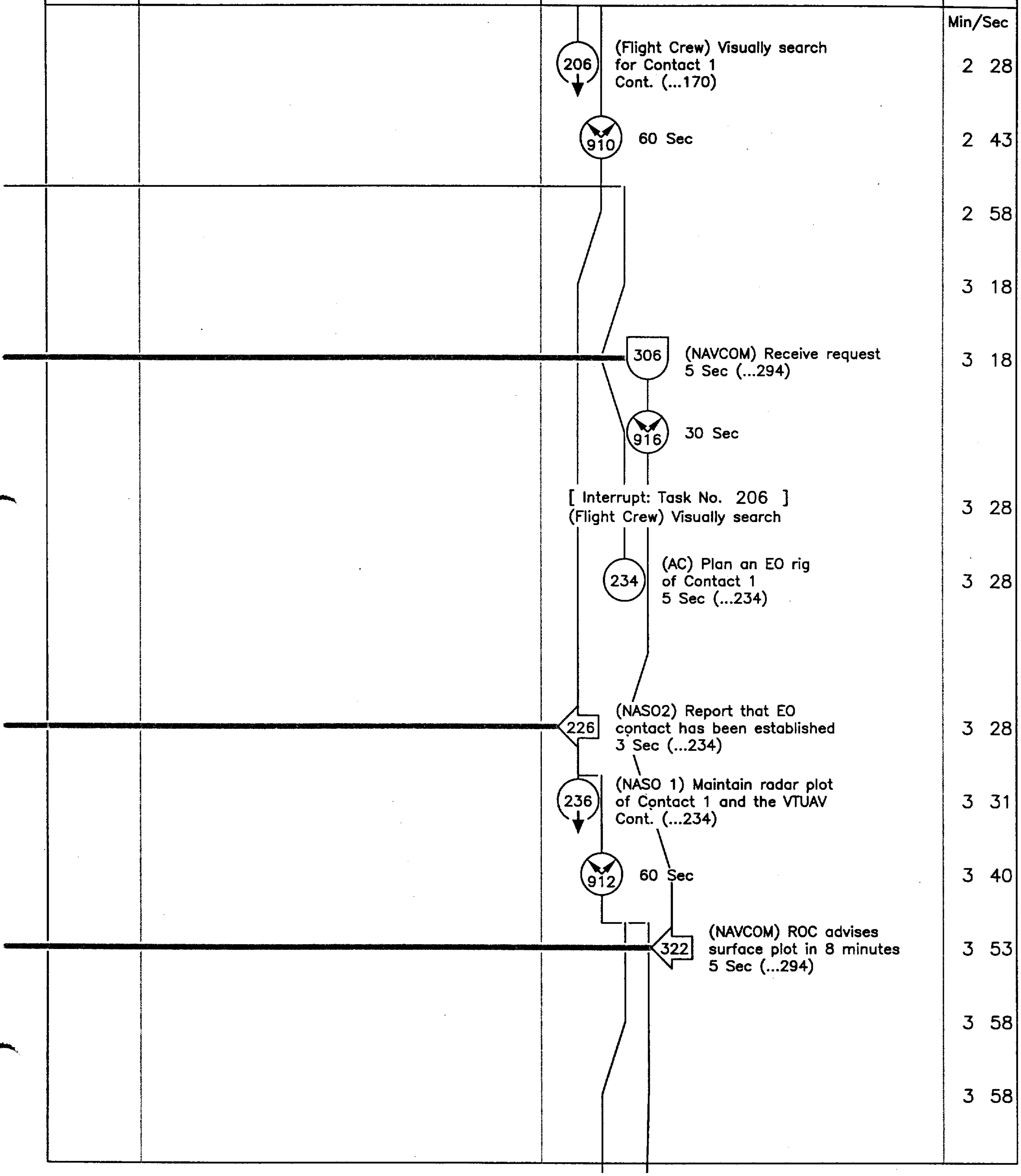
Part 1 — IP/PCT Scenario of UAV Operations — Page 15
Min 1–20 — Control of Single VTUAV During Search for Terrorist Vessel

TACNAV Up. Level Goals	UAV Pilot	Ex In



Part 1 IP/PCT Scenario of UAV Operations Page 16
Min 1–20 Control of Single VTUAV During Search for Terrorist Vessel

Ex Out	UAV Plt Up. Level Goals	Other Members of CP-140 Crew	Time



Part 1 IP/PCT Scenario of UAV Operations Page 17
Min 1–20 Control of Single VTUAV During Search for Terrorist Vessel

Time	Other Units: ROC, CPF	Mini UAVs	VTUAV
Min/Sec			
			[Interrupt: Task No. 716] Maintain track
4 3			718 Turn to track towards the intercept point 10 Sec
4 17			719 Maintain track towards the intercept point
4 31			
4 35			
4 44			
			[Interrupt: Task No. 719] Maintain track towards
4 52			721 Turn to track towards the waypoint 10 Sec
4 52			
4 57			
5 1			
5 2			722 Maintain track towards the waypoint
5 16			
5 16			

Part 1 IP/PCT Scenario of UAV Operations Page 18
Min 1–20 Control of Single VTUAV During Search for Terrorist Vessel

UAV Operator	UAV Op Up. Level Goals	TACNAV
906 20 Sec		
356 Observe fishing boat using VTUAV EO suite 15 Sec (...296); 7.1.5.2		
358 Observe that fishing boat is neutral 5 Sec (...296); 4.4.5		
360 Update surface plot with data on observed contact 8 Sec (...296); 2.1.4		
362 Advise crew of contact observed using VTUAV EO suite 5 Sec (...296); 9.4.1.3		364 Receive message 5 Sec (...296); 9.2.1.10
Loop Back to Timer: 918 Continuous		
316 Monitor message 5 Sec (...234); 9.2.1.4		314 Receive message 5 Sec (...234); 9.2.1.4
	569 End Goal 296 ... investigation of Contact 2	
277 Monitor message 5 Sec (...234); 9.2.2.3		273 Receive Message 5 Sec (...234); 9.2.2.3

TACNAV Up. Level Goals	UAV Pilot	Ex In
	[Interrupt: Task No. 354] Maintain VTUAV track	
	284 Turn VTUAV to track towards the intercept point 10 Sec (...296); 7.1.2.1	
	286 Maintain VTUAV track towards the intercept point Cont. (...296); 7.1.3	
	[Interrupt: Task No. 286] Maintain VTUAV track towards	
	370 Turn VTUAV to track towards the waypoint 10 Sec (...296); 7.1.2.1	
	366 Receive message 5 Sec (...296); 9.2.1.10	
	318 Monitor message 5 Sec (...234); 9.2.1.4	
	372 Maintain VTUAV track towards the waypoint Cont. (...296); 7.1.3	
593 End Goal 234 ... CP140 approaching and identifying Contact 4		
	275 Monitor message 5 Sec (...234); 9.2.2.3	

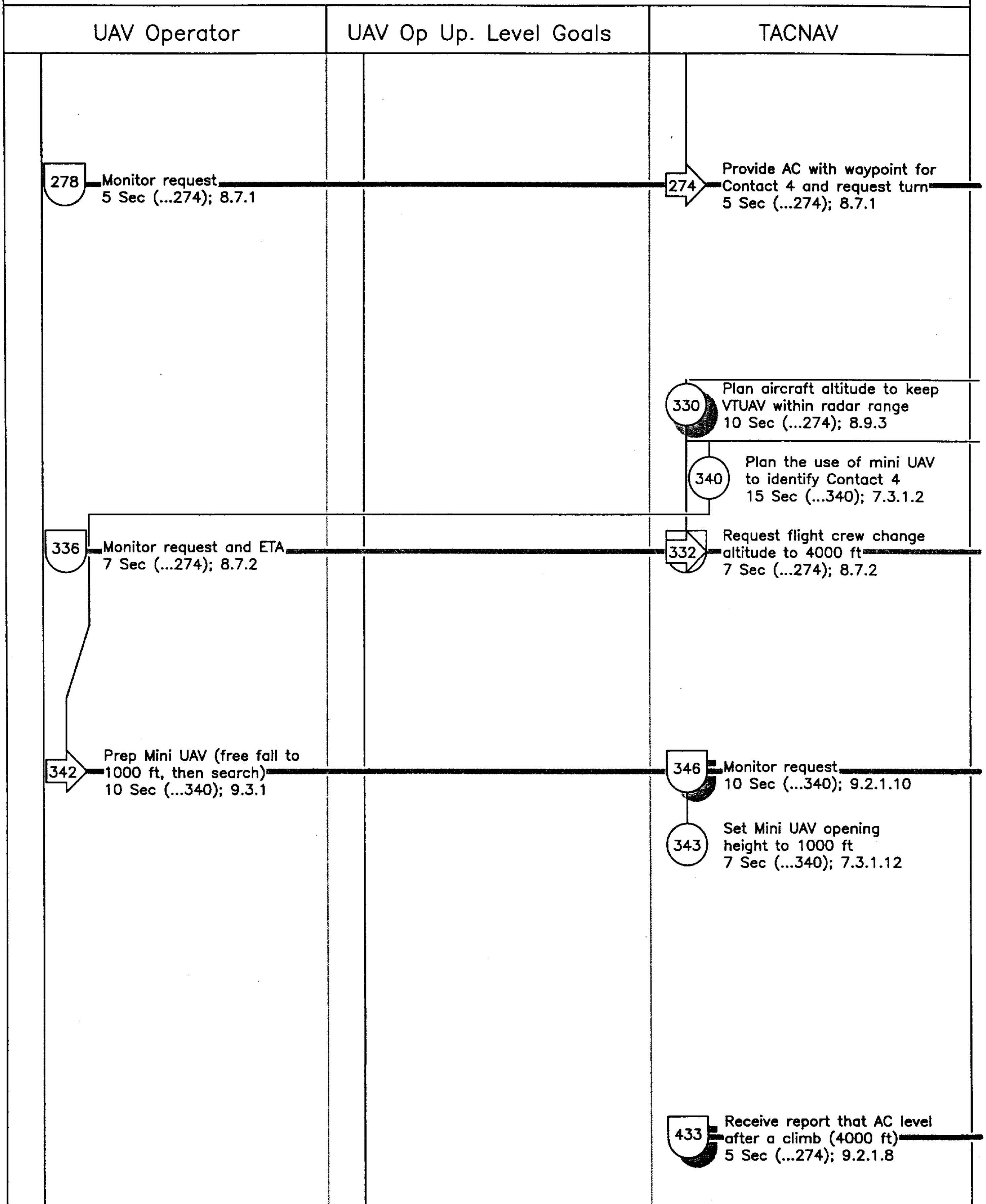
Part 1 IP/PCT Scenario of UAV Operations Page 20
Min 1–20 Control of Single VTUAV During Search for Terrorist Vessel

Ex Out	UAV Plt Up. Level Goals	Other Members of CP–140 Crew	Time Min/Sec
			4 3
		[Interrupt: Task No. 236] (NASO 1) Maintain radar plot	4 17
		268 (Pilots) Manoeuvre CP140 to observe Contact 1 and remain outside the threat envelope	4 31
		270 (NASO 1) Study Contact 1 using the CP140 EO suite 30 Sec (...234)	4 35
			4 44
			4 52
		368 (Crew) Receive message 5 Sec (...296)	4 52
			4 57
		914 15 Sec	
		312 (AC) Contact 1 has been identified (the Guppy) 5 Sec (...234)	5 1
			5 2
		[Interrupt: Task No. 268] (Pilots) Manoeuvre CP140 to	5 16
		272 (NASO 1) Advise Contact 1 not terrorist (no UAV container) 5 Sec (...234)	5 16

Part 1 Min 1—20	IP/PCT Scenario of UAV Operations Control of Single VTUAV During Search for Terrorist Vessel		Page 21
Time	Other Units: ROC, CPF	Mini UAVs	VTUAV
Min/Sec			
5 21			
5 21			
5 36			
5 46			
5 56			
5 56			
6 11			
6 21			
6 28			
7 43			
7 58			
8 3			

Part 1 IP/PCT Scenario of UAV Operations Page 22

Min 1–20 Control of Single VTUAV During Search for Terrorist Vessel



Part 1 IP/PCT Scenario of UAV Operations Page 23
Min 1–20 Control of Single VTUAV During Search for Terrorist Vessel

TACNAV Up. Level Goals	UAV Pilot	Ex In
594 274 ... CP140 in en route to Contact 4		
	280 Monitor request 5 Sec (...274); 8.7.1	
596 340 ... Mini UAV prepared for release over Contact 4		
	338 Monitor request and ETA 7 Sec (...274); 8.7.2	
	348 Monitor request 10 Sec (...340); 9.2.1.10	
597 End Goal 340 ... Mini UAV prepared for release over Contact 4		
598 416 ... surface plot updated using the CP140 radar		

Part 1 — IP/PCT Scenario of UAV Operations — Page 24

Min 1–20 — Control of Single VTUAV During Search for Terrorist Vessel

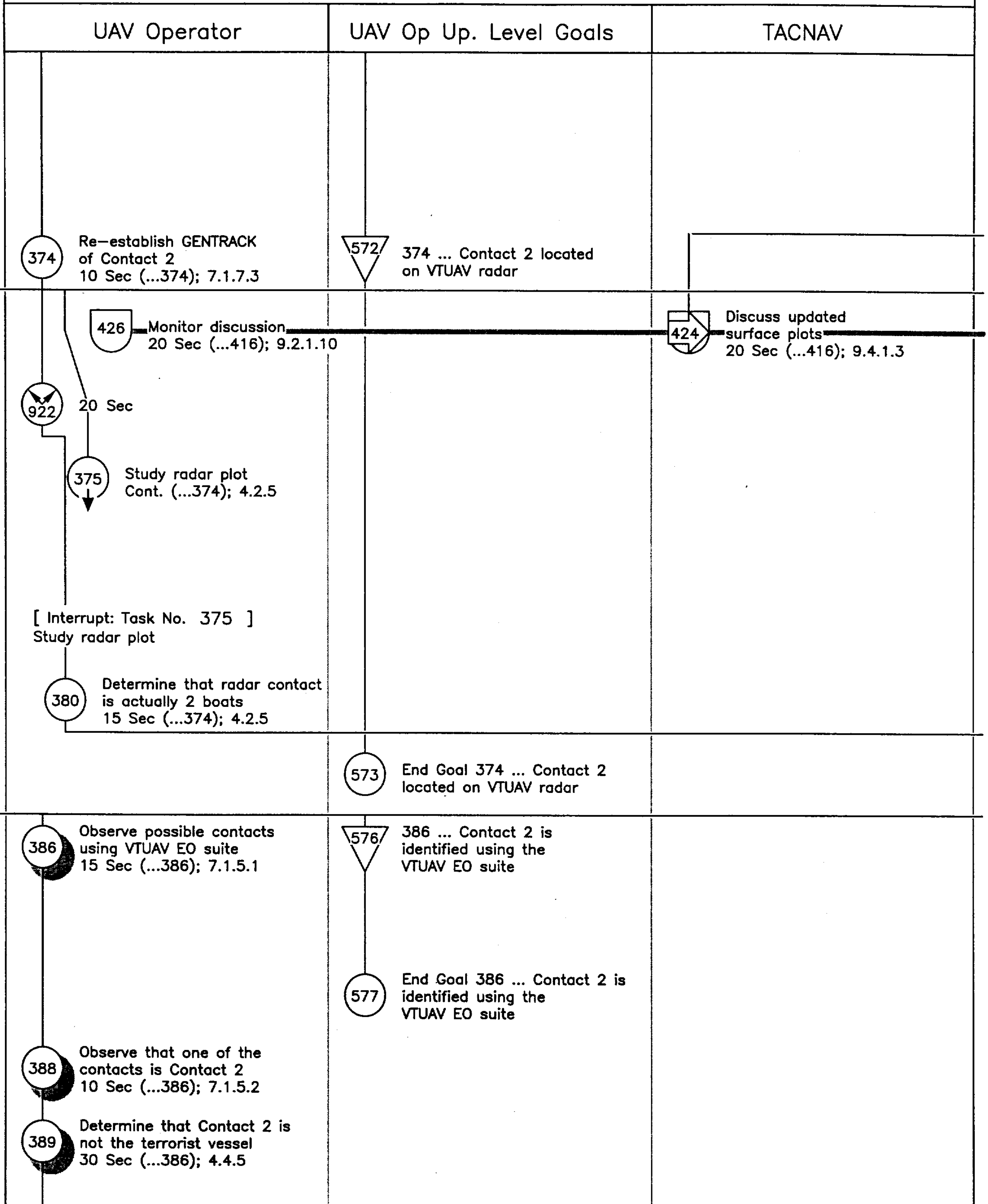
Ex Out	UAV Plt Up. Level Goals	Other Members of CP–140 Crew	Time Min/Sec
			5 21
		276 (CP140 Plt) Receive request 5 Sec (...274)	5 21
		915 10 Sec	
		320 (AC) Turn towards Contact 4 10 Sec (...274)	5 36
			5 46
			5 56
		334 (AC) Receive request for alt. change, provide Contact 4 ETA 7 Sec (...274)	5 56
		928 100 Sec	
		932 120 Sec	
		344 (ASO 1) Receive request 10 Sec (...340)	6 11
			6 21
			6 28
		416 (NASO 1) Produce updated plot of the vessels near the CPF 15 Sec (...416)	7 43
		418 (NASO 1) Establish radar contact with the MH 15 Sec (...416)	7 58
		432 (AC) Report AC level–off after climb (4000 ft) 5 Sec (...274)	8 3

Part 1 IP/PCT Scenario of UAV Operations Page 25
Min 1–20 Control of Single VTUAV During Search for Terrorist Vessel

Time Min/Sec	Other Units: ROC, CPF	Mini UAVs	VTUAV
8 8			
8 13			
8 28			
8 28			
8 38			[Interrupt: Task No. 722] Maintain track towards
8 38			724 Turn to investigate Contact 2 5 Sec
8 45			725 Maintain track towards Contact 2
8 58			
9 10			
9 23			[Interrupt: Task No. 725] Maintain track towards
9 26			727 Manoeuvre to investigate 2 boats
9 36			
9 38			
9 48			

Part 1 IP/PCT Scenario of UAV Operations

Min 1–20 Control of Single VTUAV During Search for Terrorist Vessel



Part 1 — IP/PCT Scenario of UAV Operations — Page 27

Min 1–20 — Control of Single VTUAV During Search for Terrorist Vessel

TACNAV Up. Level Goals	UAV Pilot	Ex In
595 End Goal 274 ... CP140 in en route to Contact 4		
	428 Monitor discussion 20 Sec (...416); 9.2.1.10	
	[Interrupt: Task No. 372] Maintain VTUAV track towards	
	376 Turn VTUAV to investigate Contact 2 5 Sec (...376); 7.1.2.1	
599 End Goal 416 ... surface plot updated using the CP140 radar	378 Maintain VTUAV track towards the Contact 2 Cont. (...376); 7.1.3	
	382 Plan optimal route to investigate 2 boats 15 Sec (...376); 7.1.1.2.1	
	[Interrupt: Task No. 378] Maintain VTUAV track towards	
	384 Manoeuvre VTUAV to investigate 2 boats Cont. (...376); 7.1.2.1	

Part 1 IP/PCT Scenario of UAV Operations Page 28
Min 1–20 Control of Single VTUAV During Search for Terrorist Vessel

Ex Out	UAV Plt Up. Level Goals	Other Members of CP–140 Crew	Time Min/Sec
			8 8
		420 (NASO 1) Produce updated plot of the vessels near the VTUAV 15 Sec (...416)	8 13
			8 28
		422 (NASO 1) Discuss updated surface plots 20 Sec (...416)	8 28
	574 376 ... VTUAV route (Cont. 2) is initiated and flown		8 38
			8 38
			8 45
			8 58
			9 10
			9 23
	575 End Goal 376 ... VTUAV route initiated and flown		9 26
			9 36
			9 38
			9 48

Part 1 IP/PCT Scenario of UAV Operations Page 29
Min 1–20 Control of Single VTUAV During Search for Terrorist Vessel

Time Min/Sec	Other Units: ROC, CPF	Mini UAVs	VTUAV
10 18			
10 26			[Interrupt: Task No. 727] Manoeuvre to
10 26			729 Establish a circular pattern
10 26			
10 36			
10 51			
			[Interrupt: Task No. 729] Establish a circular pattern
11 1			731 Turn to investigate a target of opportunity 5 Sec
11 6			732 Maintain track towards the target of opportunity
11 31			
11 46			
11 51			
11 59			[Interrupt: Task No. 732] Maintain track towards
11 59			734 Turn to re–establish track to TACNAV waypoint 10 Sec
11 59			

Part 1 IP/PCT Scenario of UAV Operations Page 30
Min 1–20 Control of Single VTUAV During Search for Terrorist Vessel

UAV Operator	UAV Op Up. Level Goals	TACNAV
390 Update surface plot with data on observed contacts 8 Sec (...386); 4.1.5		
392 Advise of identity of contact observed with EO (Dolphin) 10 Sec (...386); 9.4.1.3		394 Receive message 10 Sec (...386); 9.2.1.10
		404 Plan next waypoint for the VTUAV 15 Sec (...400); 7.1.1.3
429 Monitor request 10 Sec (...400); 9.2.1.10		430 Request VTUAV transit to view a target of opportunity 10 Sec (...400); 9.3.1
934 25 Sec		
438 Observe target of opportunity using VTUAV EO suite 15 Sec (...400); 7.1.5.2		
440 Observe that the target of opportunity is not a terrorist 5 Sec (...400); 4.4.5		
442 Update surface plot with data on observed contact 8 Sec (...400); 2.1.4		
444 Advise of identity of target of opportunity 5 Sec (...400); 9.4.1.3		446 Receive message 5 Sec (...400); 9.2.1.10

Part 1	IP/PCT Scenario of UAV Operations	Page 31
Min 1–20	Control of Single VTUAV During Search for Terrorist Vessel	

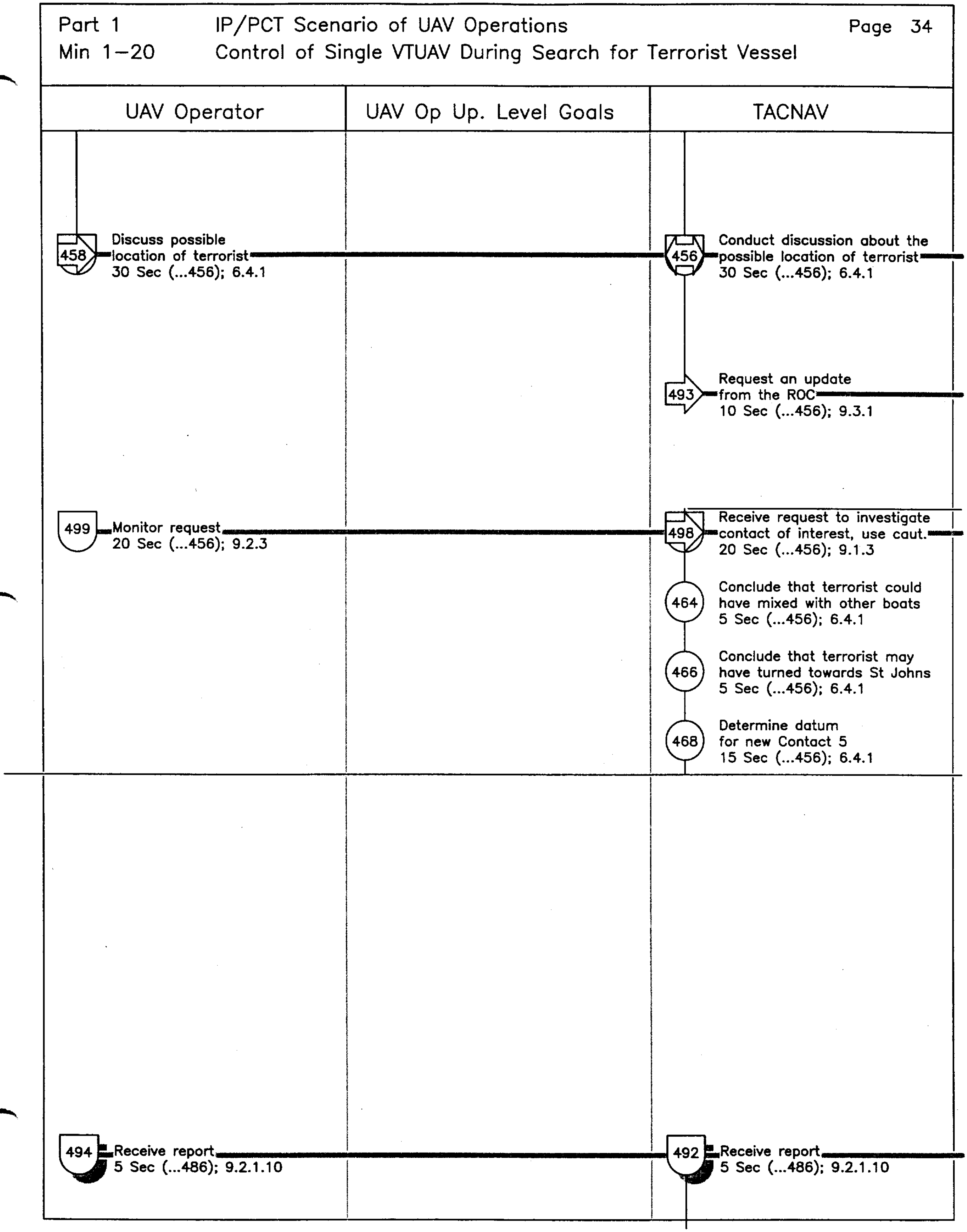
TACNAV Up. Level Goals	UAV Pilot	Ex In
	[Interrupt: Task No. 384] Manoeuvre VTUAV	
	400 Establish VTUAV in a circular pattern Cont. (...400); 7.1.2.1	
	396 Receive message 10 Sec (...386); 9.2.1.10	
	431 Receive request to view target of opportunity 10 Sec (...400); 9.1.1	
	[Interrupt: Task No. 400] Establish VTUAV in	
	434 Turn VTUAV to investigate a target of opportunity 5 Sec (...400); 7.1.2.1	
	436 Maintain VTUAV track towards the target of opportunity Cont. (...400); 7.1.3	
	[Interrupt: Task No. 436] Maintain VTUAV track towards	
	452 Turn VTUAV to re–establish track to TACNAV waypoint 10 Sec (...452); 7.1.2.1	
	448 Receive message 5 Sec (...400); 9.2.1.10	

Part 1	IP/PCT Scenario of UAV Operations	Page 32
Min 1–20	Control of Single VTUAV During Search for Terrorist Vessel	

Ex Out	UAV Plt Up. Level Goals	Other Members of CP-140 Crew	Time Min/Sec
			10 18
	578 400 ... the target of opportunity is investigated		10 26
			10 26
		398 (Crew) Receive message 10 Sec (...386)	10 26
			10 36
			10 51
			11 1
			11 6
			11 31
			11 46
			11 51
	582 452 ... VTUAV tracking towards the waypoint		11 59
			11 59
		450 (Crew) Receive message 5 Sec (...400)	11 59

Part 1 IP/PCT Scenario of UAV Operations Page 33
Min 1–20 Control of Single VTUAV During Search for Terrorist Vessel

Time Min/Sec	Other Units: ROC, CPF	Mini UAVs	VTUAV
12 4			
12 4			
12 9			735 Maintain track to TACNAV waypoint
12 34			
12 59			
13 19			
13 24			
13 29			
13 44			[Interrupt: Task No. 735] Maintain track
13 44			737 Turn towards new datum for Contact 5 10 Sec
13 54			738 Maintain track towards new datum for Contact 5
13 54			
14 14			
14 24			


Part 1
IP/PCT Scenario of UAV Operations
Page 34
Min 1–20
Control of Single VTUAV During Search for Terrorist Vessel
UAV Operator
UAV Op Up. Level Goals
TACNAV
458
Discuss possible location of terrorist
30 Sec (...456); 6.4.1
456
Conduct discussion about the possible location of terrorist
30 Sec (...456); 6.4.1
493
Request an update from the ROC
10 Sec (...456); 9.3.1
499
Monitor request
20 Sec (...456); 9.2.3
498
Receive request to investigate contact of interest, use caut.
20 Sec (...456); 9.1.3
464
Conclude that terrorist could have mixed with other boats
5 Sec (...456); 6.4.1
466
Conclude that terrorist may have turned towards St Johns
5 Sec (...456); 6.4.1
468
Determine datum for new Contact 5
15 Sec (...456); 6.4.1
494
Receive report
5 Sec (...486); 9.2.1.10
492
Receive report
5 Sec (...486); 9.2.1.10

Part 1 Min 1–20	IP/PCT Scenario of UAV Operations Control of Single VTUAV During Search for Terrorist Vessel	Page 35

TACNAV Up. Level Goals	UAV Pilot	Ex In
580 456 ... terrorist mission planning with the ROC		
	460 Discuss possible location of terrorist 30 Sec (...456); 6.4.1	
	454 Maintain VTUAV track to TACNAV waypoint Cont. (...452); 7.1.3	
	497 Monitor request 20 Sec (...456); 9.2.3	
581 End Goal 456 ... terrorist mission planning with the ROC	[Interrupt: Task No. 454] Maintain VTUAV track	
	470 Turn VTUAV towards new datum for Contact 5 10 Sec (...470); 7.1.2.1	
	474 Maintain VTUAV track towards new datum for Contact 5 Cont. (...470); 7.1.3	
	486 Recalculate VTUAV time on task 20 Sec (...486); 7.1.1.6.5	
	488 Determine that VTUAV fuelling will conflict with MH recovery 10 Sec (...486); 7.1.1.6.6	
	490 Report VTUAV time on task and conflicting refuelling time 5 Sec (...486); 9.4.1.4	

Part 1 IP/PCT Scenario of UAV Operations Page 36
Min 1–20 Control of Single VTUAV During Search for Terrorist Vessel

Ex Out	UAV Plt Up. Level Goals	Other Members of CP–140 Crew	Time Min/Sec
	579 End Goal 400 ... the target of opportunity is investigated		12 4
		462 (AC) Discuss possible location of terrorist 30 Sec (...456)	12 4
	583 End Goal 452 ... VTUAV tracking towards the waypoint		12 9
		495 Receive request for an update from ROC 10 Sec (...456); 9.1.1	12 34
		926 15 Sec	
		496 ROC requests investigation of contact of 20 nm South of VTUAV 1, use caution	12 59
			13 19
			13 24
			13 29
	584 470 ... VTUAV route (Cont. 5) is initiated and flown		13 44
			13 44
	585 End Goal 470 ... VTUAV route is initiated and flown		13 54
	586 486 ... VTUAV refuelling is planned		13 54
			14 14
	587 End Goal 486 ... VTUAV refuelling is planned		14 24

Part 1 Min 1–20	IP/PCT Scenario of UAV Operations Control of Single VTUAV During Search for Terrorist Vessel		Page 37
Time	Other Units: ROC, CPF	Mini UAVs	VTUAV
Min/Sec			[Interrupt: Task No. 738] Maintain track towards

Part 1 Min 1–20	IP/PCT Scenario of UAV Operations Control of Single VTUAV During Search for Terrorist Vessel	Page 38

UAV Operator	UAV Op Up. Level Goals	TACNAV
[Interrupt: Task No. 145] Maintain data link		938 Network Task End of Part 1

Part 1 Min 1–20	IP/PCT Scenario of UAV Operations Control of Single VTUAV During Search for Terrorist Vessel	Page 39

TACNAV Up. Level Goals	UAV Pilot	Ex In
	[Interrupt: Task No. 474] Maintain VTUAV track towards	

Part 1 Min 1–20	IP/PCT Scenario of UAV Operations Control of Single VTUAV During Search for Terrorist Vessel		Page 40
Ex Out	UAV Plt Up. Level Goals	Other Members of CP-140 Crew	Time Min/Sec

The following OSD represents in graphical form Part Two of the Composite Scenario, which is shown in Figure D-3.

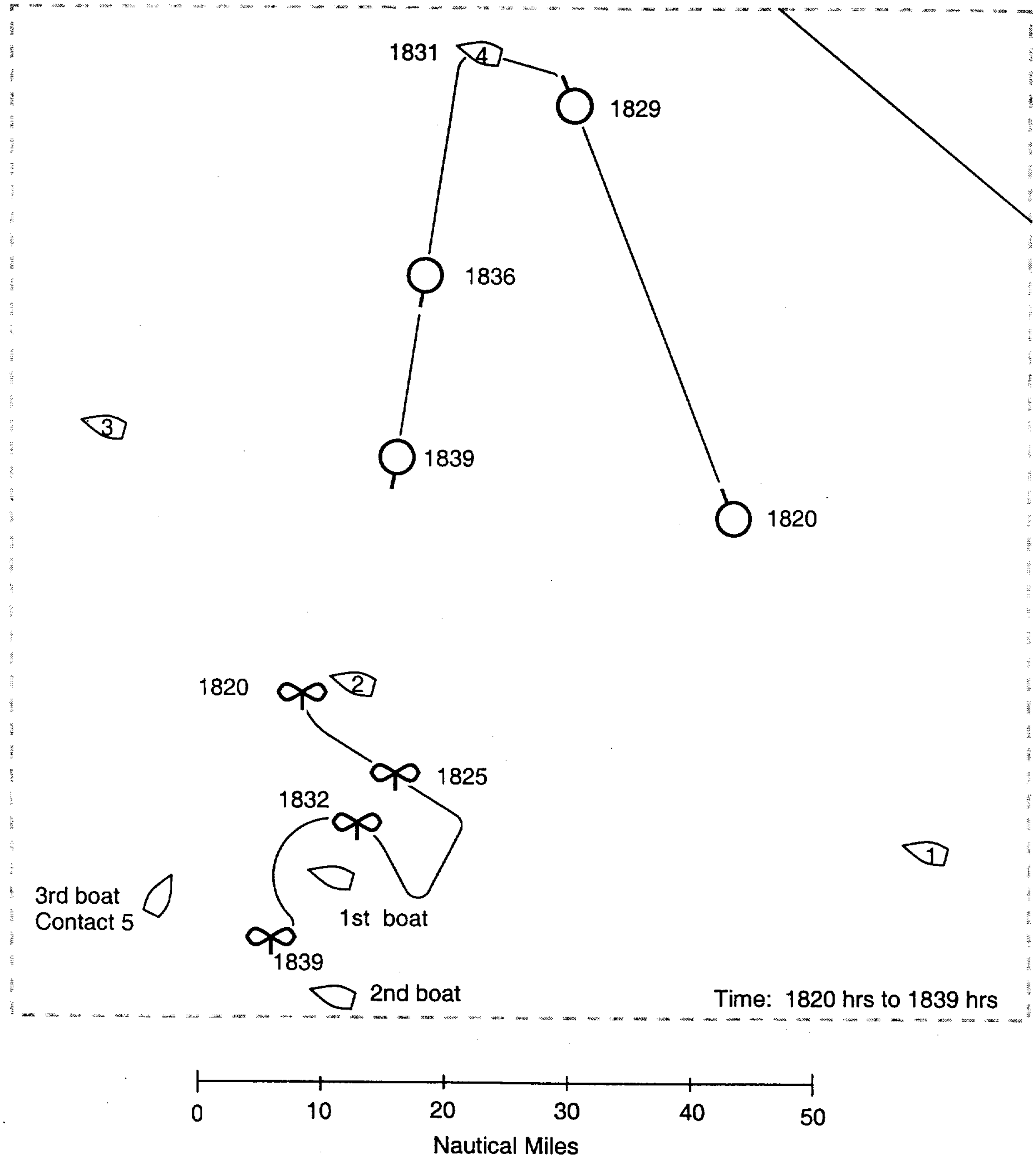


Figure D-3 Detailed Mission Scenario – Part 2

Part 2 IP/PCT Scenario of UAV Operations Page 1
Min 21–40 Control of VTUAV and Mini UAV During Search for Terrorist Vessel

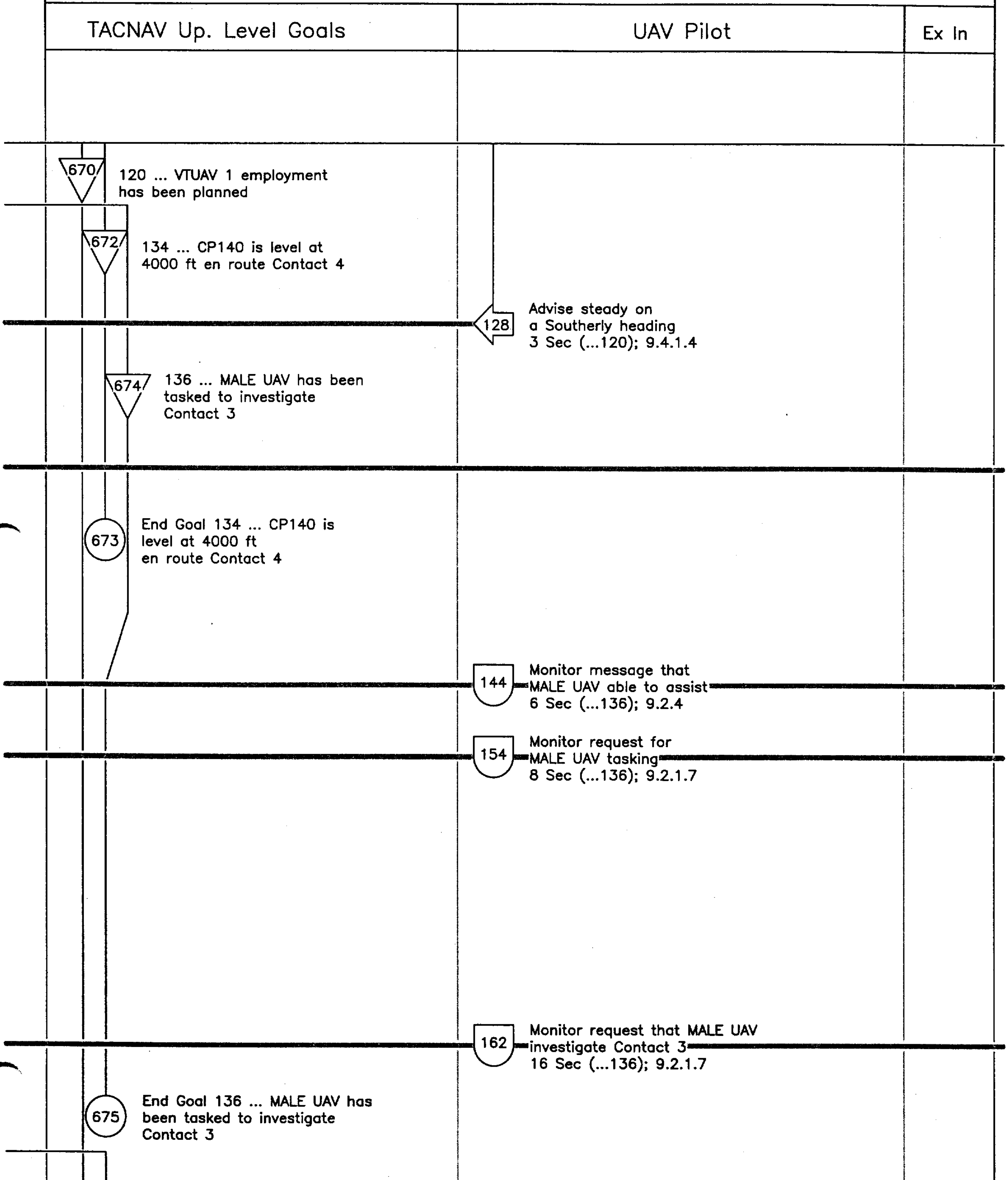
Time Min/Sec	Other Units: ROC, CPF	Mini UAVs	VTUAV
0 0	904 3 Sec		740 Maintain steady track on a Southerly heading
0 0			
0 0			
0 3			
0 3	138 (ROC) Advise MALE UAV standing by at Eastern boundary 8 Sec (...136)		
0 5			
0 6			
0 11			
0 17			
0 18			
0 21			
0 25			
0 25	157 (ROC) Receive request MALE UAV investigate Contact 3 16 Sec (...136)		
0 36			

Time and Date of Data File: 16.00 11 Jun 04

Part 2 IP/PCT Scenario of UAV Operations Page 2
Min 21–40 Control of VTUAV and Mini UAV During Search for Terrorist Vessel

UAV Operator	UAV Op Up. Level Goals	TACNAV
		900 Network Operation Start of Part 2
126 Produce VTUAV 1 radar surface plot about new datum 14 Sec (...120); 7.1.7.1		120 Plan route for VTUAV 1 transit to Contact 5 6 Sec (...120); 7.1.1.1
130 Receive message regarding VTUAV flight path 3 Sec (...120); 9.2.1.6		132 Receive message regarding VTUAV flight path 3 Sec (...120); 9.2.1.6
		122 Verify that 4000 ft is adequate for control of VTUAV 12 Sec (...120); 7.1.9.1
146 Monitor message that MALE UAV able to assist 6 Sec (...136); 9.2.4		142 Receive message that MALE UAV able to assist 6 Sec (...136); 9.2.4
152 Monitor request for MALE UAV tasking 8 Sec (...136); 9.2.1.7		148 Request that MALE UAV probe Contact 3, 7000ft and above 8 Sec (...136); 9.3.1
		124 Monitor progress of CP–140 3 Sec (...120); 8.9.3
		164 Receive radar plot data from the VTUAV 1 4 Sec (...120); 2.1.1
		166 Receive radar plot data from NASO1 6 Sec (...120); 2.1.1
160 Monitor request that MALE UAV investigate Contact 3 16 Sec (...136); 9.2.1.7		158 Monitor request that MALE UAV investigate Contact 3 16 Sec (...136); 9.2.1.7
		168 Fuse radar plot data and select 3 boats to investigate 16 Sec (...120); 2.5.2.1

Part 2 IP/PCT Scenario of UAV Operations Page 3
Min 21–40 Control of VTUAV and Mini UAV During Search for Terrorist Vessel



Part 2	IP/PCT Scenario of UAV Operations	Page 4
Min 21–40	Control of VTUAV and Mini UAV During Search for Terrorist Vessel	

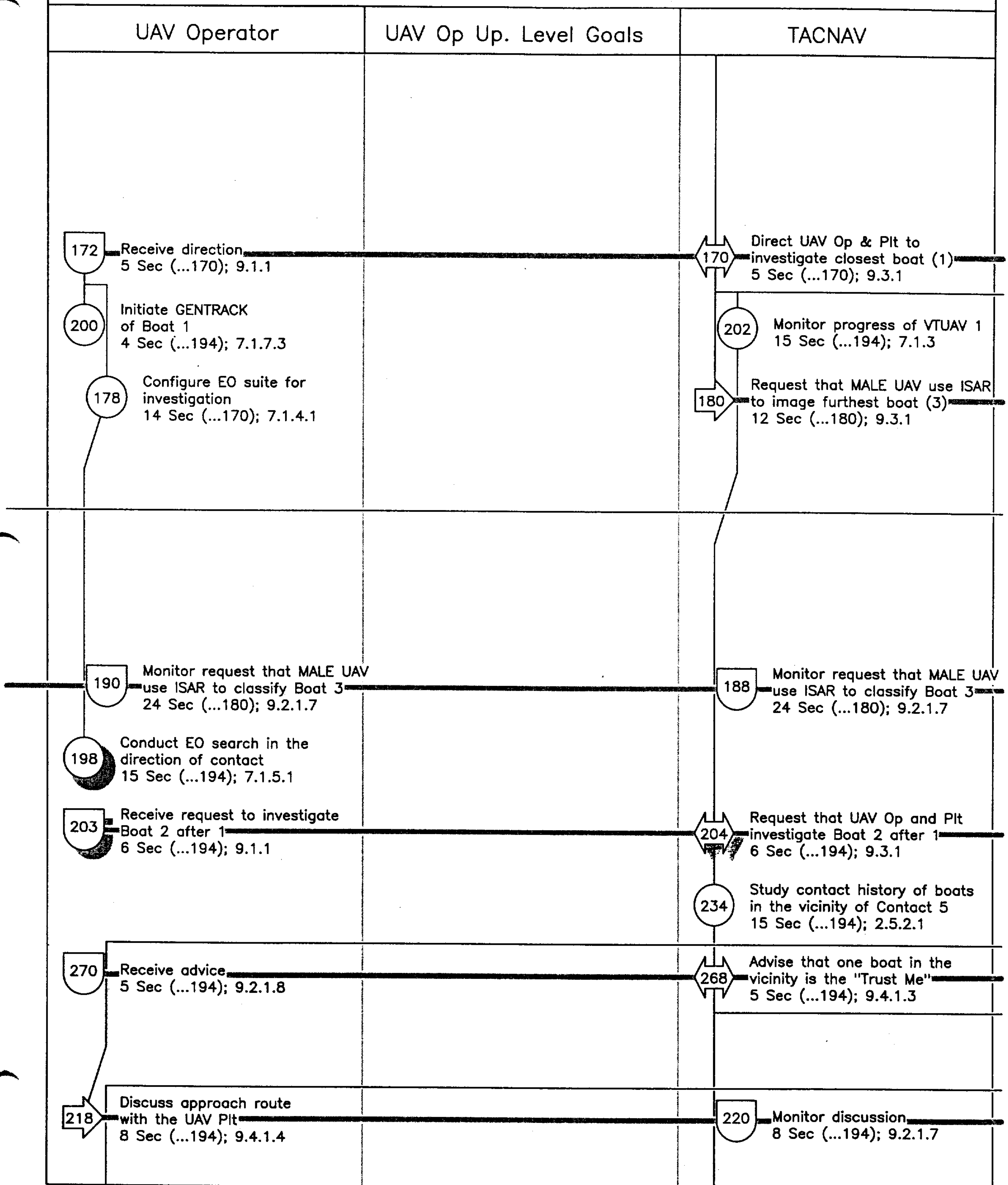
Ex Out	UAV Plt Up. Level Goals	Other Members of CP–140 Crew	Time Min/Sec
		906 540 Sec	0 0
		134 (AC) Maintain CP140 in level flight at 4000 ft to Contact 4 Cont. (...134)	0 0
			0 0
			0 3
		136 (NAVCOM) MALE UAV standing by at Eastern boundary to assist 8 Sec (...136)	0 3
			0 5
			0 6
		140 (NAVCOM) Advise that MALE UAV able to assist 6 Sec (...136)	0 11
		150 (NAVCOM) Receive request for MALE UAV tasking 8 Sec (...136)	0 17
			0 18
			0 21
			0 25
		156 (NAVCOM) Request MALE UAV investigate Contact 3 16 Sec (...136)	0 25
			0 36

Part 2 IP/PCT Scenario of UAV Operations Page 5
Min 21–40 Control of VTUAV and Mini UAV During Search for Terrorist Vessel

Time Min/Sec	Other Units: ROC, CPF	Mini UAVs	VTUAV
0 47			
0 47			
0 47			
0 52			
0 52			
1 0			
1 3			741 Heading change to maintain track while approaching Boat 1
1 3			
1 4	186 (ROC) Receive request MALE UAV use ISAR to classify Boat 3 24 Sec (...180)		
1 6			
1 7			
1 15			
1 28	918 300 Sec		
1 29			
1 29			

Part 2 IP/PCT Scenario of UAV Operations Page 6

Min 21–40 Control of VTUAV and Mini UAV During Search for Terrorist Vessel



Part 2 — IP/PCT Scenario of UAV Operations — Page 7
Min 21–40 — Control of VTUAV and Mini UAV During Search for Terrorist Vessel

TACNAV Up. Level Goals	UAV Pilot	Ex In
671 End Goal 120 ... VTUAV 1 employment has been planned		
676 170 ... UAV Op and Plt intend to investigate Boat 1		
	174 Receive direction 5 Sec (...170); 9.1.1	
678 180 ... the MALE UAV will conduct ISAR imaging of Boat 3	176 Plan route to approach Boat 1 from the East 8 Sec (...170); 7.1.1.1	
	194 Insert waypoints to define VTUAV 1 route 3 Sec (...194); 7.1.1.3	
	196 Control VTUAV 1 to maintain track while approaching Boat 1 10 Sec (...194); 7.1.2.1	
	212 Plan stealthy approach to Boat 1 from the East 14 Sec (...194); 7.1.1.1	
	192 Monitor request that MALE UAV use ISAR to classify Boat 3 24 Sec (...180); 9.2.1.7	
677 End Goal 170 ... UAV Op and Plt intend to investigate Boat 1		
	205 Receive request to investigate Boat 2 after 1 6 Sec (...194); 9.1.1	
	214 Plot approach route 12 Sec (...194); 7.1.1.10	
	272 Receive advice 5 Sec (...194); 9.2.1.8	
	232 Monitor VTUAV 1 progress towards Boat 1 turning point 10 Sec (...194); 7.1.3	
	216 Discuss approach route with the UAV Op 8 Sec (...194); 9.4.1.4	

Part 2 IP/PCT Scenario of UAV Operations Page 8
Min 21–40 Control of VTUAV and Mini UAV During Search for Terrorist Vessel

Ex Out	UAV Plt Up. Level Goals	Other Members of CP–140 Crew	Time Min/Sec
			0 47
			0 47
			0 47
			0 52
		182 (NAVCOM) Receive request 12 Sec (...180)	0 52
	680 194 ... VTUAV 1 is cautiously approaching Boat 1		1 0
			1 3
			1 3
		184 (NAVCOM) Request MALE UAV use ISAR to classify Boat 3 24 Sec (...180)	1 4
			1 6
			1 7
			1 15
			1 28
			1 29
			1 29

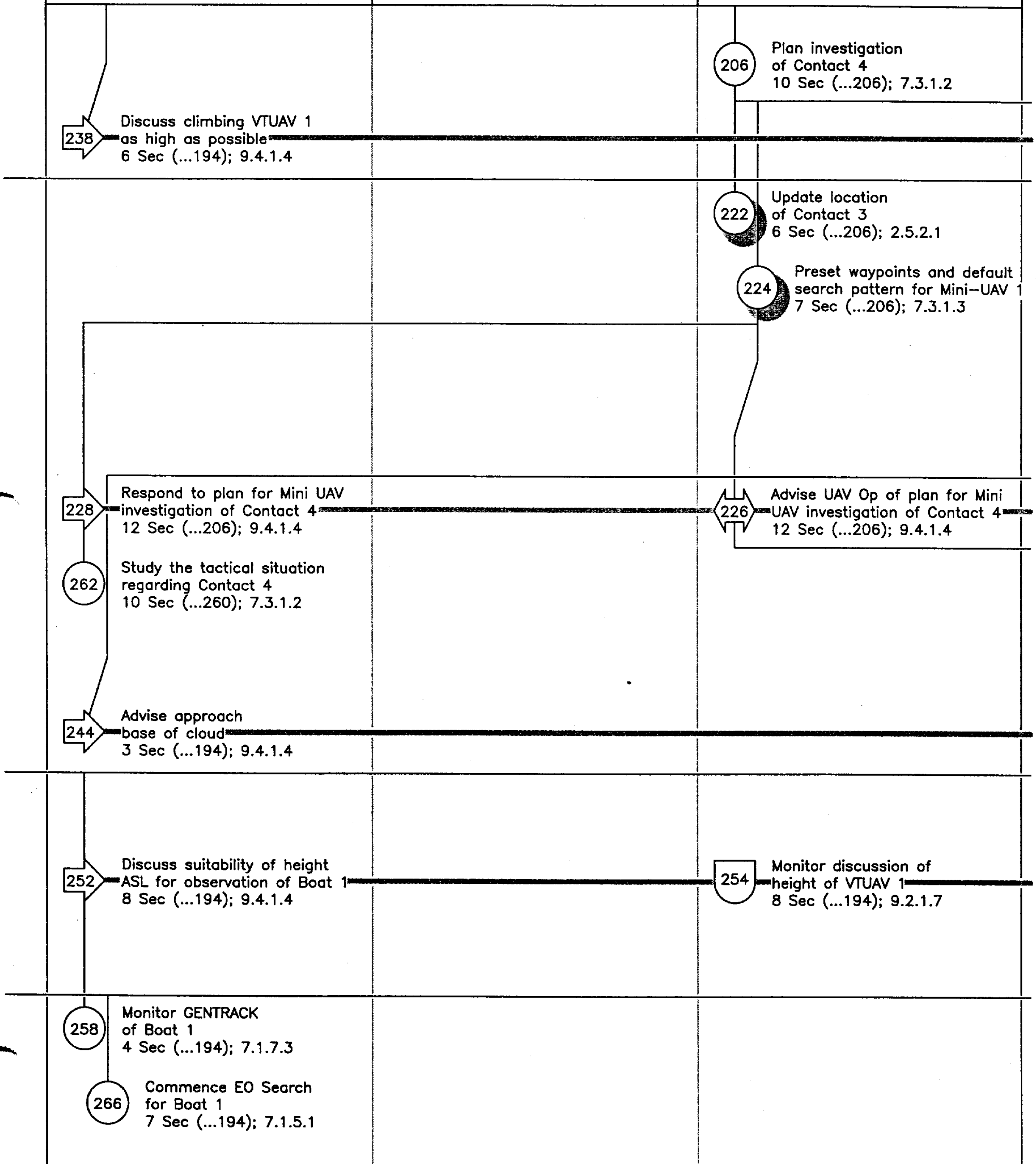
Part 2 IP/PCT Scenario of UAV Operations Page 9
Min 21–40 Control of VTUAV and Mini UAV During Search for Terrorist Vessel

Time Min/Sec	Other Units: ROC, CPF	Mini UAVs	VTUAV
1 33			
1 39			
1 43			
1 44			[Interrupt: Task No. 740] Maintain steady track on
1 47			742 Climb initiated to a height just below cloud
1 50			743 Climb maintained
1 50			
2 2			
2 2			
2 3			
2 6			[Interrupt: Task No. 743] Climb maintained
2 6			744 Level–off from climb clear of cloud
2 13			
2 42			745 Turn to South to maintain route

Part 2 IP/PCT Scenario of UAV Operations Page 10

Min 21–40 Control of VTUAV and Mini UAV During Search for Terrorist Vessel

UAV Operator	UAV Op Up. Level Goals	TACNAV



Part 2 — IP/PCT Scenario of UAV Operations — Page 11
Min 21–40 — Control of VTUAV and Mini UAV During Search for Terrorist Vessel

TACNAV Up. Level Goals	UAV Pilot	Ex In
682 — 206 ... plan for investigation of Contact 4 using a Mini UAV		
	236 — Discuss climbing VTUAV 1 as high as possible 6 Sec (...194); 9.4.1.4	
	240 — Initiate a climb to a height ASL just below cloud 5 Sec (...194); 7.1.2.2	
	242 — Maintain climb 13 Sec (...194); 7.1.3	
	230 — Monitor discussion regarding investigation of Contact 4 12 Sec (...206); 9.2.1.7	
683 — End Goal 206 ... plan for investigation of Contact 4 using a Mini UAV	260 — Study the tactical situation regarding Contact 4 10 Sec (...260); 7.3.1.2	
684 — 260 ... CP140 on final run–in for deployment of Mini UAV 1		
	246 — Receive warning of base of cloud 3 Sec (...194); 9.2.1.6	
	248 — Level–off from climb, visually confirm clear of cloud 6 Sec (...194); 7.1.2.2	
	250 — Discuss suitability of height ASL for observation of Boat 1 8 Sec (...194); 9.4.1.4	
	908 — 30 Sec	
	256 — Monitor VTUAV 1 systems and fuel flow Cont. (...194); 7.1.9.4	
	264 — Turn VTUAV 1 towards South to maintain route 14 Sec (...194); 7.1.2.1	

Part 2 IP/PCT Scenario of UAV Operations Page 12
Min 21–40 Control of VTUAV and Mini UAV During Search for Terrorist Vessel

Ex Out	UAV Plt Up. Level Goals	Other Members of CP–140 Crew	Time Min/Sec
			1 33
			1 39
		208 (NASO 1) Establish GENTRACK of Contact 4 6 Sec (...206)	1 43
			1 44
		210 (NASO 1) Direct CP140 pilot for homing down Contact 4 MLA 15 Sec (...206)	1 47
			1 50
			1 50
			2 2
			2 2
			2 3
			2 6
			2 6
			2 13
			2 42

Part 2 — IP/PCT Scenario of UAV Operations — Page 13

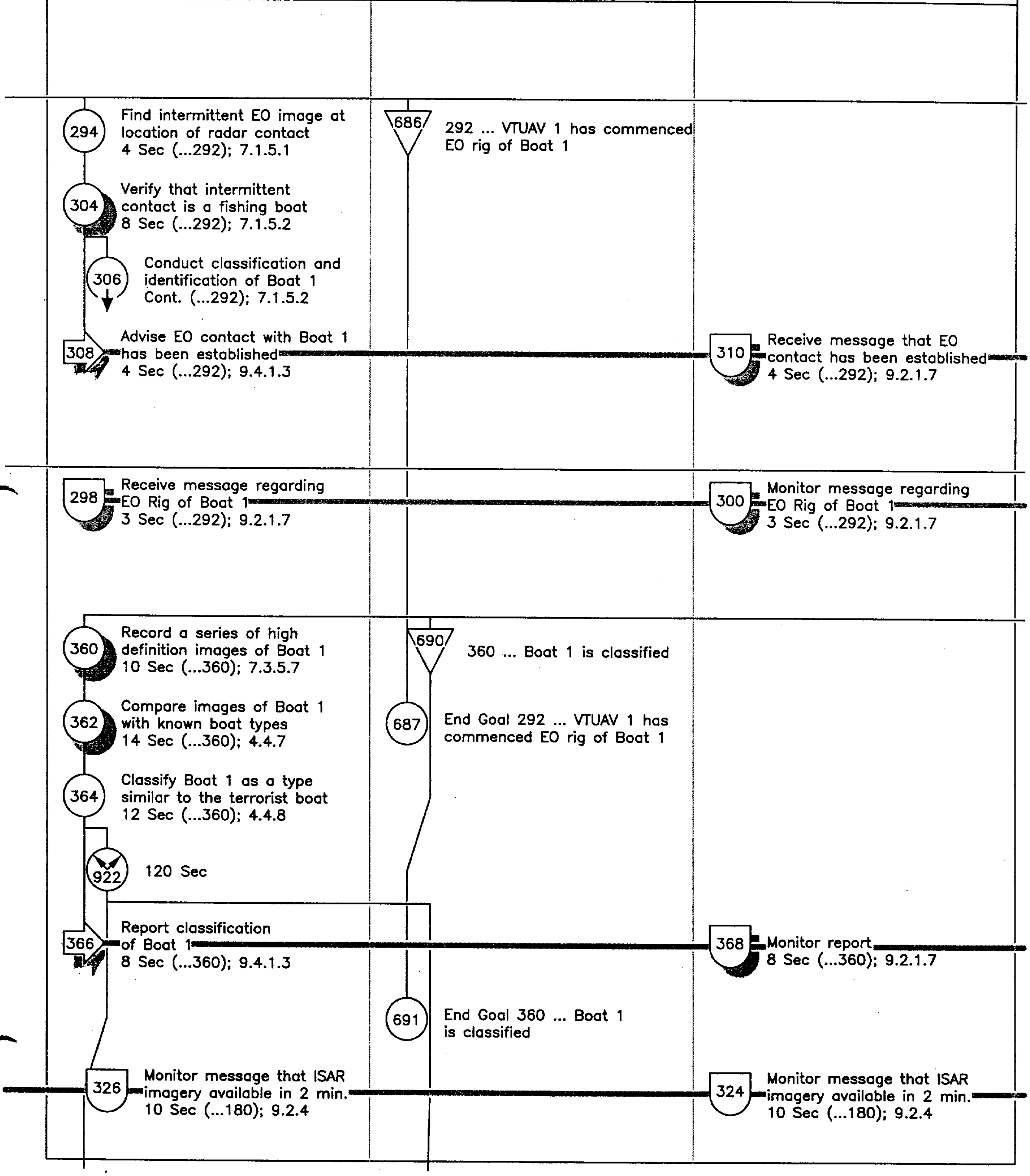
Min 21–40 — Control of VTUAV and Mini UAV During Search for Terrorist Vessel

Time Min/Sec	Other Units: ROC, CPF	Mini UAVs	VTUAV
3 6			
3 56			[Interrupt: Task No. 745] Turn to South to
3 57			746 Turn to WNW to initiate EO Rig of Boat 1
4 8			
4 8			
4 11			
4 56			747 Turn to circle Boat 1
5 6			748 Circular route maintained about Boat 1
5 16			
5 30			
5 42			
5 50			
6 28	318 (ROC) Advise that ISAR imagery of Boat 3 available in 2 min. 10 Sec (...180)		

Part 2 IP/PCT Scenario of UAV Operations Page 14

Min 21–40 Control of VTUAV and Mini UAV During Search for Terrorist Vessel

UAV Operator	UAV Op Up. Level Goals	TACNAV



Part 2 — IP/PCT Scenario of UAV Operations — Page 15

Min 21–40 — Control of VTUAV and Mini UAV During Search for Terrorist Vessel

TACNAV Up. Level Goals	UAV Pilot	Ex In

910 — 60 Sec

[Interrupt: Task No. 256]
Monitor VTUAV 1 systems

292 — Turn VTUAV 1 towards WNW and start EO Rig of Boat 1
15 Sec (...292); 7.1.2.1

312 — Receive message that EO contact has been established
4 Sec (...292); 9.2.1.7

914 — 45 Sec

296 — Advise UAV Op that Rig of Boat 1 has commenced
3 Sec (...292); 9.4.1.3

314 — Turn VTUAV 1 to circle Boat 1
10 Sec (...292); 7.1.2.1

316 — Maintain circular route around Boat 1
Cont. (...292); 7.1.3

370 — Receive classification report
8 Sec (...360); 9.2.1.8

372 — Check VTUAV 1 systems in case Boat 1 is terrorist boat
6 Sec (...360); 7.1.9.4

328 — Monitor message that ISAR imagery available in 2 min.
10 Sec (...180); 9.2.4

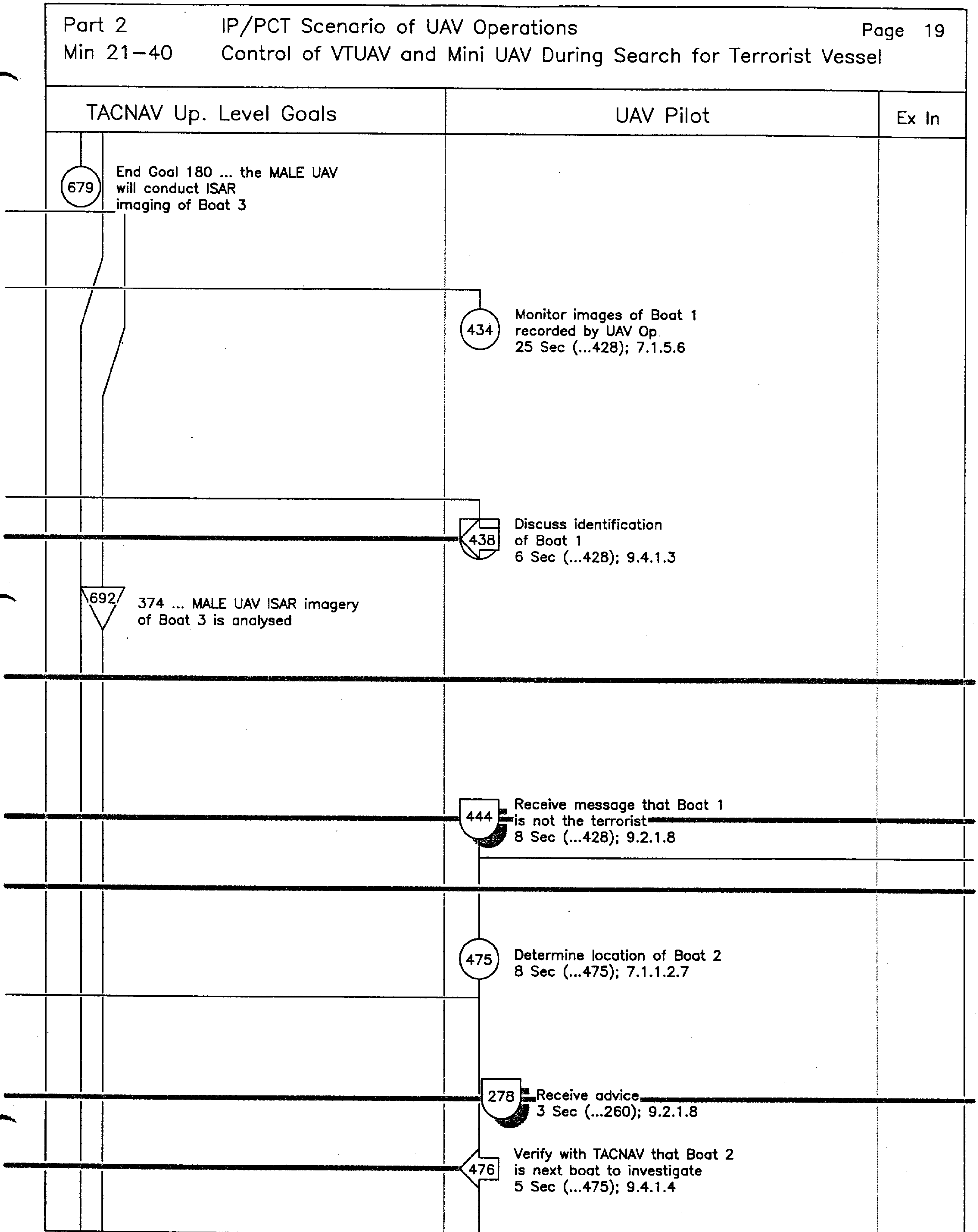
Part 2 Min 21–40	IP/PCT Scenario of UAV Operations Control of VTUAV and Mini UAV During Search for Terrorist Vessel	Page 16

Ex Out	UAV Plt Up. Level Goals	Other Members of CP–140 Crew	Time Min/Sec
	681 End Goal 194 ... VTUAV 1 is cautiously approaching Boat 1		3 6
			3 56
			3 57
			4 8
			4 8
		302 (AC) Monitor message regarding EO Rig of Boat 1 3 Sec (...292);	4 11
			4 56
			5 6
			5 16
			5 30
			5 42
			5 50
		320 (NAVCOM) Receive message that ISAR imagery available 2 min. 10 Sec (...180)	6 28

Part 2 Min 21–40	IP/PCT Scenario of UAV Operations Control of VTUAV and Mini UAV During Search for Terrorist Vessel		Page 17
Time	**Other Units: ROC, CPF**	**Mini UAVs**	**VTUAV**
Min/Sec			
6 38	920 120 Sec		
7 42			
7 49			
8 4			
8 16			
8 34			
8 38			
8 38	374 (ROC) Advise that ISAR imagery of Boat 3 available on website 12 Sec (...374)		
8 40			
8 45			
8 50			
8 53			
8 56			
9 0			
9 1			

Part 2 IP/PCT Scenario of UAV Operations Page 18
Min 21–40 Control of VTUAV and Mini UAV During Search for Terrorist Vessel

UAV Operator	UAV Op Up. Level Goals	TACNAV
428 Abeam Boat 1, zoom in on boat Registration No and Name 7 Sec (...428); 7.1.5.4	698 428 ... Boat 1 is identified and determined to be neutral	
430 Record high definition images of Registration No and Name 15 Sec (...428); 7.1.5.5		
431 Record images of boat structure 12 Sec (...428); 7.1.5.5		
432 Study bow mid–ships and bow structure for lethal UAV 18 Sec (...428); 7.1.5.2		
436 Discuss identification of Boat 1 6 Sec (...428); 9.4.1.3		437 Monitor discussion about identification of Boat 1 6 Sec (...428); 9.2.1.7
		378 Monitors message 12 Sec (...374); 9.2.4
440 Conclude that Boat 1 is the "Trust Me" and not terrorist 5 Sec (...428); 4.3.3		
442 Advise crew that Boat 1 is not the terrorist 8 Sec (...428); 9.4.1.3		443 Receive message that Boat 1 is not the terrorist 8 Sec (...428); 9.2.1.8
		380 Request NAS01 download ISAR imagery, analyse and report 6 Sec (...374); 9.3.1
	699 End Goal 428 ... Boat 1 is identified and determined to be neutral	
280 Receive advice 3 Sec (...260); 9.2.1.8		276 Receive advice 3 Sec (...260); 9.2.1.8
478 Monitor discussion that Boat 2 is next boat to investigate 5 Sec (...475); 9.2.1.7		477 Confirm that Boat 2 is next boat for VTUAV to investigat 5 Sec (...475); 9.4.1.4

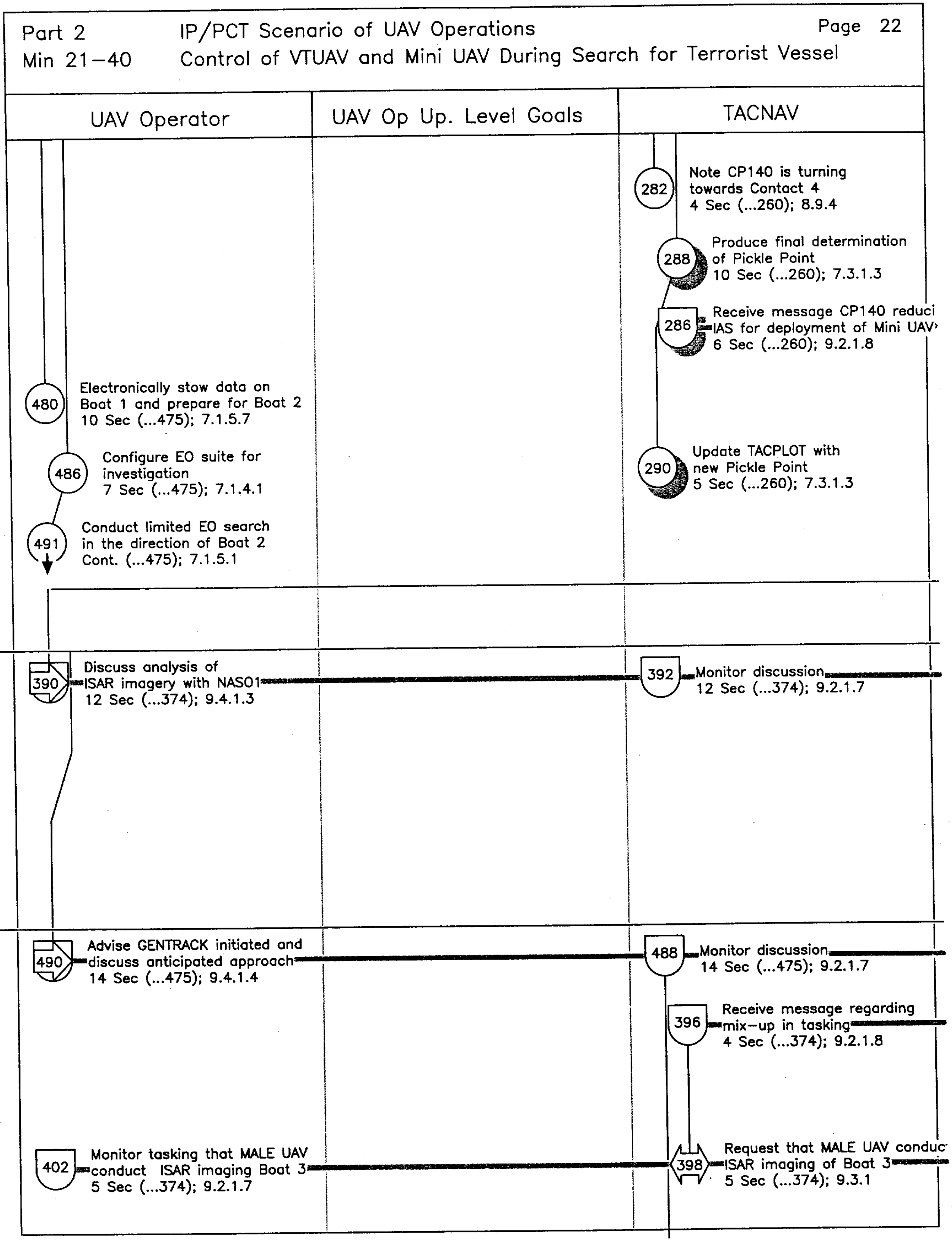

Part 2
Min 21–40
IP/PCT Scenario of UAV Operations
Control of VTUAV and Mini UAV During Search for Terrorist Vessel
Page 19
TACNAV Up. Level Goals
UAV Pilot
Ex In
679
End Goal 180 ... the MALE UAV will conduct ISAR imaging of Boat 3
434
Monitor images of Boat 1 recorded by UAV Op
25 Sec (...428); 7.1.5.6
438
Discuss identification of Boat 1
6 Sec (...428); 9.4.1.3
692
374 ... MALE UAV ISAR imagery of Boat 3 is analysed
444
Receive message that Boat 1 is not the terrorist
8 Sec (...428); 9.2.1.8
475
Determine location of Boat 2
8 Sec (...475); 7.1.1.2.7
278
Receive advice
3 Sec (...260); 9.2.1.8
476
Verify with TACNAV that Boat 2 is next boat to investigate
5 Sec (...475); 9.4.1.4

Part 2 IP/PCT Scenario of UAV Operations Page 20
Min 21–40 Control of VTUAV and Mini UAV During Search for Terrorist Vessel

Ex Out	UAV Plt Up. Level Goals	Other Members of CP–140 Crew	Time Min/Sec
			6 38
			7 42
			7 49
			8 4
			8 16
			8 34
			8 38
		376 (NAVCOM) Receives message 12 Sec (...374)	8 38
			8 40
		445 (AC) Receive message that Boat 1 is not the terrorist 8 Sec (...428)	8 45
		382 (NASO1) Receive request 6 Sec (...374)	8 50
	702 475 ... plan for approaching Boat 2 is complete		8 53
		384 (NASO1) Download/extract ISAR imagery from ROC image server 18 Sec (...374)	8 56
		274 (AC) Advise that CP140 is 2 minutes back from Contact 4 3 Sec (...260)	9 0
			9 1

Part 2 IP/PCT Scenario of UAV Operations Page 21
Min 21–40 Control of VTUAV and Mini UAV During Search for Terrorist Vessel

Time	Other Units: ROC, CPF	Mini UAVs	VTUAV
Min/Sec			
9 3			
9 3			
9 3			
9 6			
9 10			
9 13			
9 25			
9 29			
			[Interrupt: Task No. 748] Circular route maintained
9 33			749 Heading change to track towards Boat 2
9 33			
9 41			
9 45			
9 45			


Part 2
Min 21–40
IP/PCT Scenario of UAV Operations
Control of VTUAV and Mini UAV During Search for Terrorist Vessel
Page 22
UAV Operator
UAV Op Up. Level Goals
TACNAV
282
Note CP140 is turning towards Contact 4
4 Sec (...260); 8.9.4
288
Produce final determination of Pickle Point
10 Sec (...260); 7.3.1.3
286
Receive message CP140 reduci IAS for deployment of Mini UAV
6 Sec (...260); 9.2.1.8
480
Electronically stow data on Boat 1 and prepare for Boat 2
10 Sec (...475); 7.1.5.7
486
Configure EO suite for investigation
7 Sec (...475); 7.1.4.1
290
Update TACPLOT with new Pickle Point
5 Sec (...260); 7.3.1.3
491
Conduct limited EO search in the direction of Boat 2
Cont. (...475); 7.1.5.1
390
Discuss analysis of ISAR imagery with NASO1
12 Sec (...374); 9.4.1.3
392
Monitor discussion
12 Sec (...374); 9.2.1.7
490
Advise GENTRACK initiated and discuss anticipated approach
14 Sec (...475); 9.4.1.4
488
Monitor discussion
14 Sec (...475); 9.2.1.7
396
Receive message regarding mix-up in tasking
4 Sec (...374); 9.2.1.8
402
Monitor tasking that MALE UAV conduct ISAR imaging Boat 3
5 Sec (...374); 9.2.1.7
398
Request that MALE UAV conduc ISAR imaging of Boat 3
5 Sec (...374); 9.3.1

TACNAV Up. Level Goals	UAV Pilot	Ex In
	482 Plan approach to Boat 2 from East like approach to Boat 1 7 Sec (...475); 7.1.1.2.1	
	483 Plot approach route 12 Sec (...475); 7.1.1.10	
	484 Insert waypoints to define VTUAV 1 route 8 Sec (...475); 7.1.1.3	
	[Interrupt: Task No. 316] Maintain circular route	
	485 Control VTUAV 1 to maintain track while approaching Boat 2 Cont. (...475); 7.1.2.1	
	940 300 Sec	
	487 Request GENTRACK of Boat 2 and discuss anticipated approach 14 Sec (...475); 9.4.1.4	
685 End Goal 260 ... CP140 on final run–in for deployment of Mini UAV 1		
	404 Monitor tasking that MALE UAV conduct ISAR imaging Boat 3 5 Sec (...374); 9.2.1.7	

Part 2 IP/PCT Scenario of UAV Operations Page 24
Min 21–40 Control of VTUAV and Mini UAV During Search for Terrorist Vessel

Ex Out	UAV Plt Up. Level Goals	Other Members of CP–140 Crew	Time Min/Sec
		[Interrupt: Task No. 134] (AC) Maintain CP140 in level	9 3
			9 3
		284 (AC) Advise CP140 reducing IAS for deployment of Mini UAV 6 Sec (...260)	9 3
			9 6
		912 90 Sec	9 10
		386 (NASO1) Analyse imagery and determine that image is Boat 1 not Boat 3 15 Sec (...374)	9 13
			9 25
		388 (NASO1) Discuss analysis of ISAR imagery with UAV Op 12 Sec (...374)	9 29
			9 33
			9 33
		394 (NASO1) Advise that MALE UAV & VTUAV 1 investigated same boat 4 Sec (...374)	9 41
			9 45
		400 (NAVCOM) Receive ROC tasking 5 Sec (...374)	9 45

Part 2 — IP/PCT Scenario of UAV Operations — Page 25

Min 21–40 — Control of VTUAV and Mini UAV During Search for Terrorist Vessel

Time Min/Sec	Other Units: ROC, CPF	Mini UAVs	VTUAV
9 47			
9 50	408 (ROC) Receive request to conduct ISAR imaging of Boat 3 14 Sec (...374)		
10 2			
10 4	924 90 Sec		
10 39			
10 51			
10 54			
10 59			
11 4			
11 6		750 Deploy and fall to initial operating altitude	
11 6			
11 11		751 Establish level flight at 1000 ft	
11 13			
11 17		752 Turn towards Contact 4	

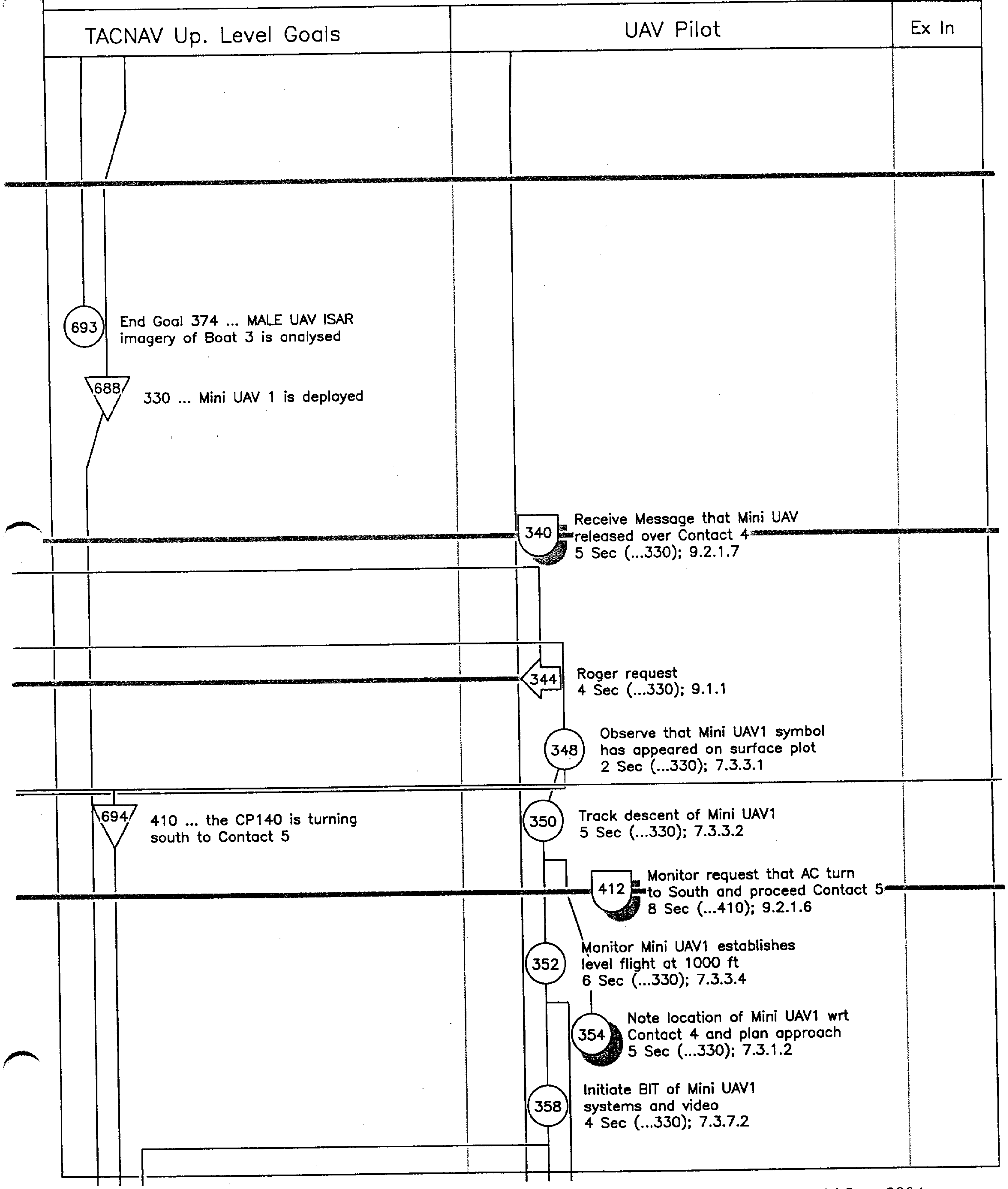
Part 2 IP/PCT Scenario of UAV Operations Page 26
Min 21–40 Control of VTUAV and Mini UAV During Search for Terrorist Vessel

UAV Operator	UAV Op Up. Level Goals	TACNAV
		492 Monitor progress of VTUAV 1 10 Sec (...475); 7.1.3
336 Receive Message that Mini UAV released over Contact 4 5 Sec (...330); 9.2.1.7		338 Receive Message that Mini UAV released over Contact 4 5 Sec (...330); 9.2.1.7
		916 5 Sec
342 Request that UAV Plt advise when Mini UAV1 image is steady 4 Sec (...330); 9.3.1		
		346 Observe that Mini UAV1 symbol has appeared on surface plot 2 Sec (...330); 7.3.3.1
411 Monitor request that AC turn to South and proceed Contact 5 8 Sec (...410); 9.2.1.6		410 Request that AC turn to South and proceed to Contact 5 8 Sec (...410); 9.3.1

Part 2 Min 21–40

IP/PCT Scenario of UAV Operations

Control of VTUAV and Mini UAV During Search for Terrorist Vessel



Part 2 IP/PCT Scenario of UAV Operations Page 28
Min 21–40 Control of VTUAV and Mini UAV During Search for Terrorist Vessel

Ex Out	UAV Plt Up. Level Goals	Other Members of CP–140 Crew	Time Min/Sec
			9 47
		406 (NAVCOM) Request that MALE UAV conduct ISAR imaging of Boat 3 14 Sec (...374)	9 50
	703 End Goal 475 ... plan for approaching Boat 2 is complete		10 2
			10 4
		330 (AC) Review on–line checklist for Mini UAV deployment 12 Sec (...330)	10 39
		332 (AC) Observe that the Mini UAV released at Pickle Point 3 Sec (...330)	10 51
		334 (AC) Advise crew that Mini UAV released over Contact 4 5 Sec (...330); 9.4.1.3	10 54
			10 59
			11 4
			11 6
		414 (AC) Receive direction and advise turning to Contact 5 8 Sec (...410)	11 6
			11 11
		415 (AC) Initiate turn and track towards Contact 5 (4000 ft) 25 Sec (...410)	11 13
			11 17

Part 2 IP/PCT Scenario of UAV Operations Page 29

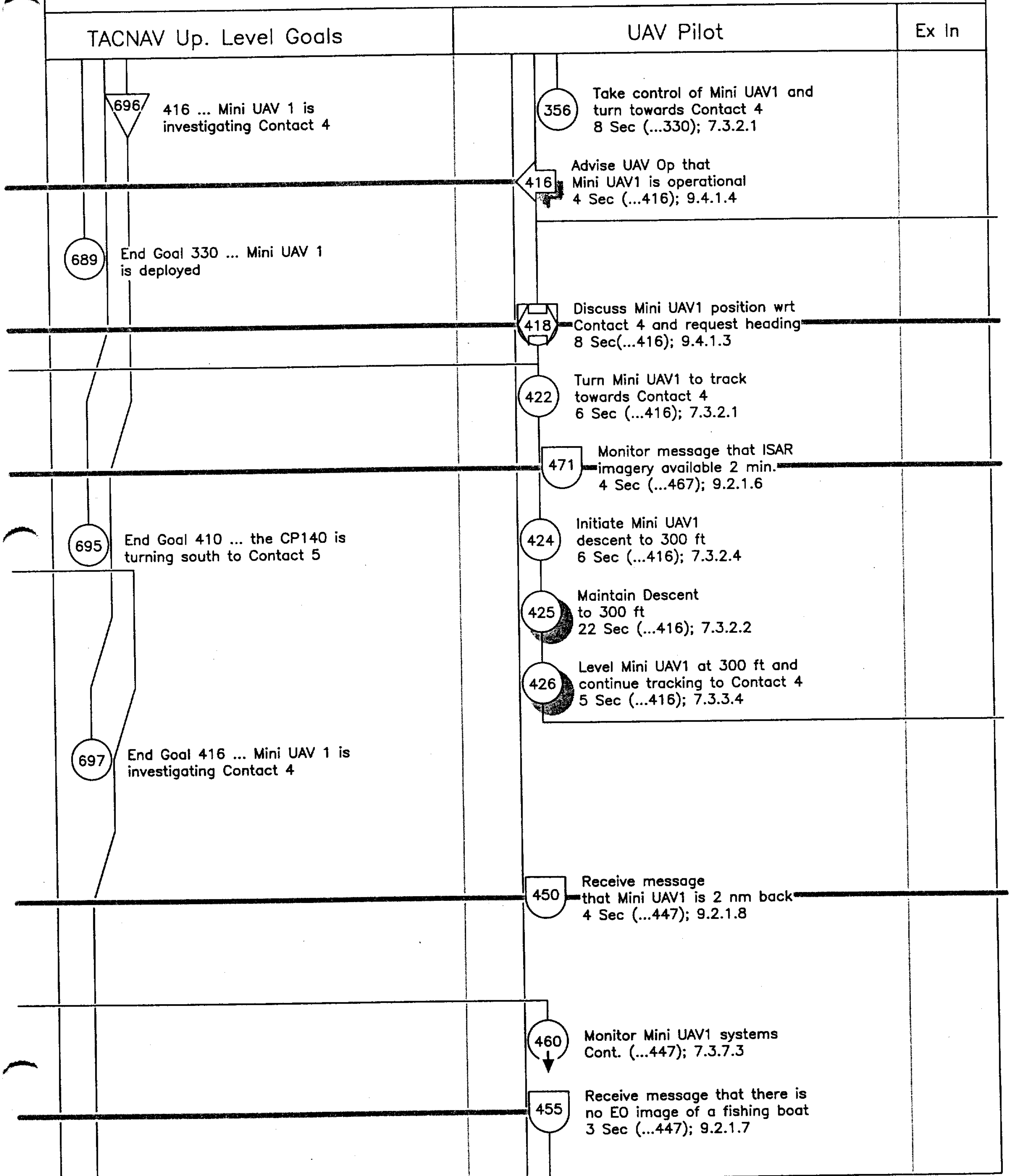
Min 21–40 Control of VTUAV and Mini UAV During Search for Terrorist Vessel

Time Min/Sec	Other Units: ROC, CPF	Mini UAVs	VTUAV
11 19			
11 21			
11 25			
11 25			
11 33		753 Turn to maintain track towards Contact 4	
11 34	467 (ROC) Advise that ISAR imagery of Boat 3 available in 2 min. 4 Sec (...467)		
11 39	936 120 Sec	754 Initiate descent to 300 ft	
11 45		755 Maintain descent to 300 ft	
12 7		756 Level-off at 300 ft and track towards Contact 4	
12 12			
12 27			
12 27			
12 31			
12 40			
12 40			

Part 2 IP/PCT Scenario of UAV Operations Page 30
Min 21–40 Control of VTUAV and Mini UAV During Search for Terrorist Vessel

UAV Operator	UAV Op Up. Level Goals	TACNAV
[Interrupt: Task No. 306] Conduct classification and		
417 Receive message that Mini UAV1 ready for recce of Contact 4 4 Sec (...416); 9.2.1.7		
421 Monitor discussion about Mini UAV1 position wrt Contact 4 8 Sec (...416); 9.2.1.7		420 Monitor discussion about Mini UAV1 position wrt Contact 4 8 Sec (...416); 9.2.1.7
470 Monitor message that ISAR imagery available 2 min. 4 Sec (...467); 9.2.1.6		469 Monitor message that ISAR imagery available 2 min. 4 Sec (...467); 9.4.1.3
448 Receive message that Mini UAV1 is 2 nm back 4 Sec (...447); 9.2.1.8		449 Monitor message that Mini UAV1 is 2 nm back 4 Sec (...447); 9.2.1.7
452 Studies Mini UAV1 video and determines it is serviceable 9 Sec (...447); 7.3.7.3		
454 Advises that there is no EO image of a fishing boat 3 Sec (...447); 9.4.1.3		456 Monitor message that there is no EO image of a fishing boat 3 Sec (...447); 9.2.1.7

Part 2 IP/PCT Scenario of UAV Operations Page 31
Min 21–40 Control of VTUAV and Mini UAV During Search for Terrorist Vessel



Part 2 IP/PCT Scenario of UAV Operations Page 32

Min 21–40 Control of VTUAV and Mini UAV During Search for Terrorist Vessel

Ex Out	UAV Plt Up. Level Goals	Other Members of CP–140 Crew	Time Min/Sec
			11 19
			11 21
			11 25
		419 (NASO1) Provide UAV Plt with magnetic track to Contact 4 8 Sec (...416)	11 25
			11 33
		468 (NAVCOM) Receive message that ISAR imagery available 2 min. 4 Sec (...467)	11 34
			11 39
			11 45
			12 7
		926 15 Sec	12 12
	700 447 ... investigation of Contact 4 by Mini UAV 1 has commenced		12 27
		447 (NASO1) Advise UAV Op and Plt that Mini UAV1 is 2 nm back 4 Sec (...447)	12 27
			12 31
			12 40
			12 40

Part 2 IP/PCT Scenario of UAV Operations Page 33
Min 21–40 Control of VTUAV and Mini UAV During Search for Terrorist Vessel

Time Min/Sec	Other Units: ROC, CPF	Mini UAVs	VTUAV
12 43			
12 48			
12 55			
13 0			
13 10		[Interrupt: Task No. 756] Level–off at 300 ft	
13 24		757 Initiate automatic over–flight	
13 38	546 (ROC) Advise that new ISAR imagery of Boat 3 available 12 Sec (...546)		
13 40			
13 40			
13 44			
13 50			
13 56			
13 56			
14 4			

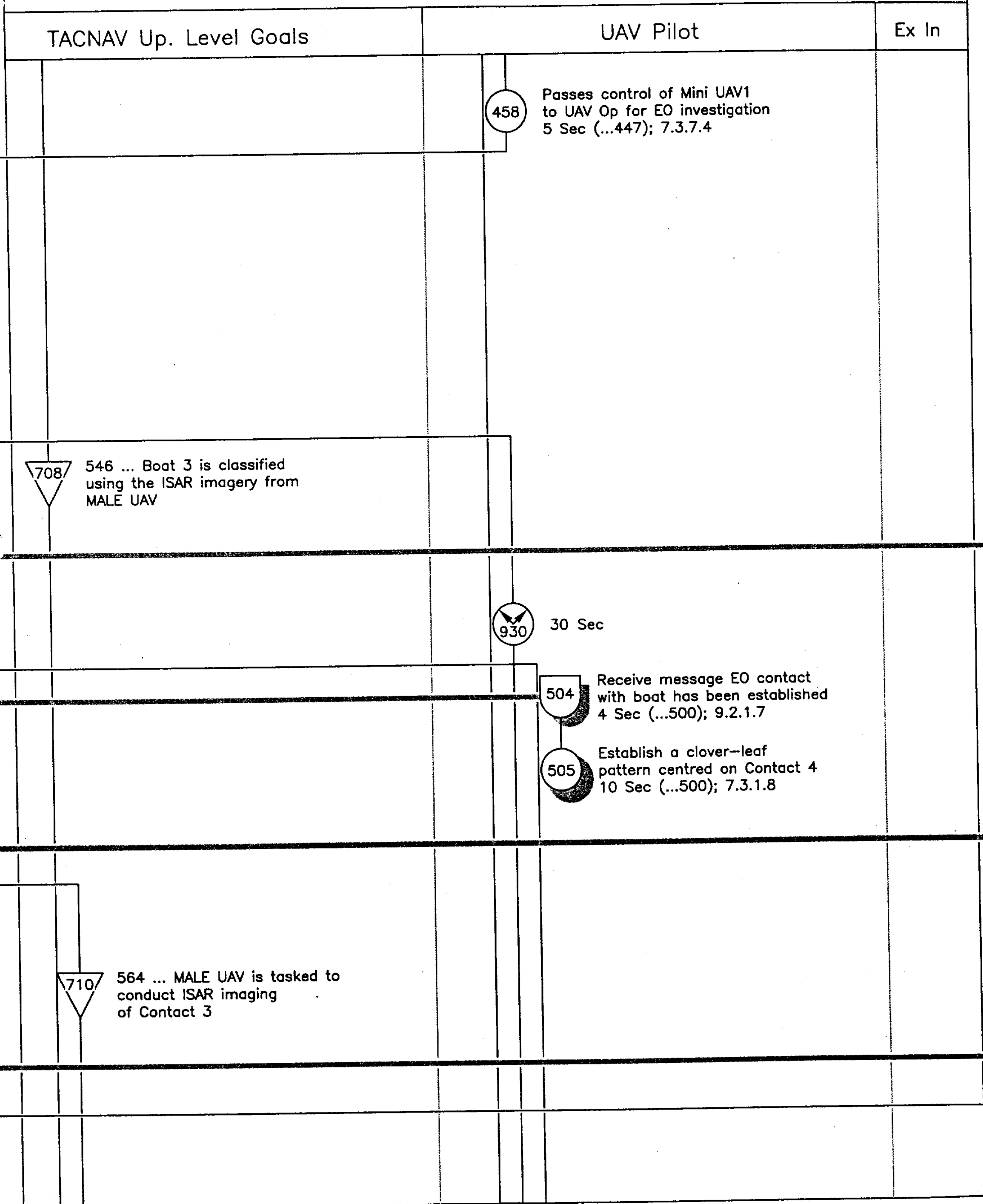
Part 2 IP/PCT Scenario of UAV Operations

Min 21–40 Control of VTUAV and Mini UAV During Search for Terrorist Vessel

UAV Operator	UAV Op Up. Level Goals	TACNAV
462 Establish translating waypoint at location of Contact 4 7 Sec (...447); 7.3.1.3		
464 Drag Mini UAV1 FOV trapezoid over Contact 4 and zoom 5 Sec (...447); 7.3.5.8		
466 Initiate automatic over–flight function and start recording 10 Sec (...447);7.3.2.5		
928 30 Sec		
		548 Monitors message 12 Sec (...546); 9.2.4
500 Conduct classification and ID of Contact 4 Cont. (...500); 4.4.5	704 500 ... identity of Contact 4 is determined using Mini UAV 1	
502 Advise EO contact with boat has been established 4 Sec (...500); 9.4.1.3		503 Receive message EO contact with boat has been established 4 Sec (...500); 9.2.1.7
510 Record a series of high definition images of Cont. 4 12 Sec (...500); 7.3.5.7		
		550 Request NAS01 download ISAR imagery, analyse and report 6 Sec (...546); 9.3.1
932 30 Sec		
511 Compare images of Contact 4 with known boat types 8 Sec (...500); 4.4.7		
		564 Request that MALE UAV use ISAR to image Contact 3 8 Sec (...564); 9.3.1
512 Classify Contact 4 as a fishing boat 5 Sec (...500); 4.4.8		

Part 2 IP/PCT Scenario of UAV Operations Page 35

Min 21–40 Control of VTUAV and Mini UAV During Search for Terrorist Vessel

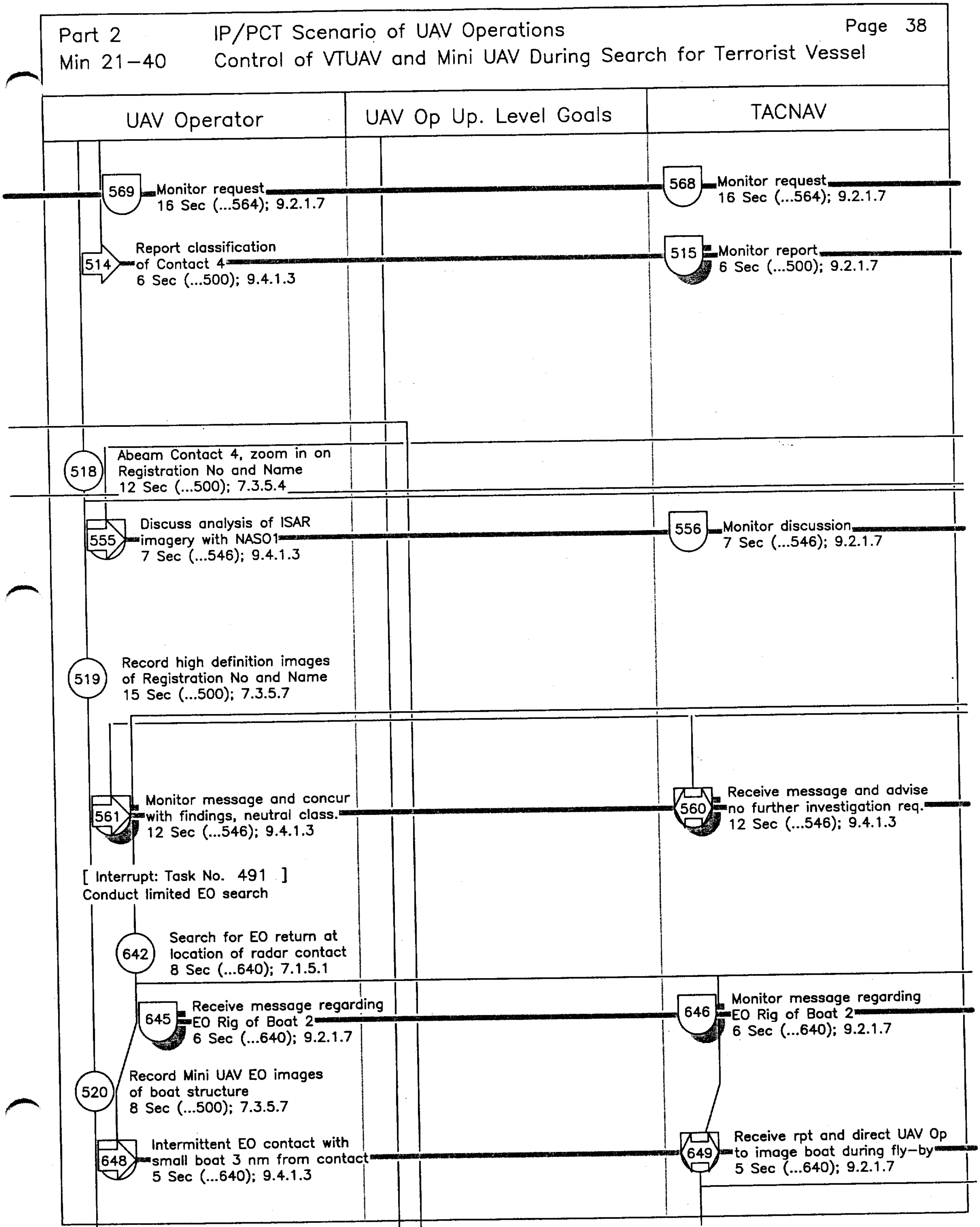


Part 2 IP/PCT Scenario of UAV Operations Page 36
Min 21–40 Control of VTUAV and Mini UAV During Search for Terrorist Vessel

Ex Out	UAV Plt Up. Level Goals	Other Members of CP–140 Crew	Time Min/Sec
			12 43
			12 48
			12 55
			13 0
	701 End Goal 447 ... investigation of Contact 4 by Mini UAV 1 has commenced		13 10
			13 24
		547 (NAVCOM) Receives message 12 Sec (...546)	13 38
			13 40
			13 40
			13 44
		551 (NASO1) Receive request 6 Sec (...546)	13 50
		552 (NASO1) Download/extract ISAR imagery from ROC image server 14 Sec (...546)	13 56
		565 (NAVCOM) Receive request 8 Sec (...564)	13 56
			14 4

Control of VTUAV and Mini UAV During Search for Terrorist Vessel

Time Min/Sec	Other Units: ROC, CPF	Mini UAVs	VTUAV
14 4	567 (ROC) Receive request and advise imagery in 3 minutes 16 Sec (...564)		
14 9			
14 10		[Interrupt: Task No. 757] Initiate automatic over-flight	
14 13	934 180 Sec	758 Overfly Contact 4 and initiate cloverleaf pattern	
14 26	938 120 Sec		
14 28			
14 33			[Interrupt: Task No. 749] Heading change to track
14 35			759 Turn towards WNW and track towards Boat 2
14 41			
14 44			
14 48			
14 48			
14 48			
14 55			
14 56			


Part 2
Min 21–40
IP/PCT Scenario of UAV Operations
Control of VTUAV and Mini UAV During Search for Terrorist Vessel
Page 38
UAV Operator
UAV Op Up. Level Goals
TACNAV
569
Monitor request
16 Sec (...564); 9.2.1.7
568
Monitor request
16 Sec (...564); 9.2.1.7
514
Report classification
of Contact 4
6 Sec (...500); 9.4.1.3
515
Monitor report
6 Sec (...500); 9.2.1.7
518
Abeam Contact 4, zoom in on
Registration No and Name
12 Sec (...500); 7.3.5.4
555
Discuss analysis of ISAR
imagery with NASO1
7 Sec (...546); 9.4.1.3
556
Monitor discussion
7 Sec (...546); 9.2.1.7
519
Record high definition images
of Registration No and Name
15 Sec (...500); 7.3.5.7
561
Monitor message and concur
with findings, neutral class.
12 Sec (...546); 9.4.1.3
560
Receive message and advise
no further investigation req.
12 Sec (...546); 9.4.1.3
[Interrupt: Task No. 491]
Conduct limited EO search
642
Search for EO return at
location of radar contact
8 Sec (...640); 7.1.5.1
645
Receive message regarding
EO Rig of Boat 2
6 Sec (...640); 9.2.1.7
646
Monitor message regarding
EO Rig of Boat 2
6 Sec (...640); 9.2.1.7
520
Record Mini UAV EO images
of boat structure
8 Sec (...500); 7.3.5.7
648
Intermittent EO contact with
small boat 3 nm from contact
5 Sec (...640); 9.4.1.3
649
Receive rpt and direct UAV Op
to image boat during fly–by
5 Sec (...640); 9.2.1.7

Part 2 IP/PCT Scenario of UAV Operations Page 39

Min 21–40 Control of VTUAV and Mini UAV During Search for Terrorist Vessel

TACNAV Up. Level Goals	UAV Pilot	Ex In

570 Monitor request
16 Sec (...564); 9.2.1.7

516 Receive classification report
6 Sec (...500); 9.2.1.10

506 On over–flight of Cont. 4 set
Mini UAV1 to execute pattern
6 Sec (...500); 7.3.2.5

711 End Goal 564 ... MALE UAV is
tasked to conduct ISAR
imaging of Contact 3

508 Monitor route of Mini UAV1
around Contact 4
Cont. (...500); 7.3.3.3

[Interrupt: Task No. 485]
Control VTUAV 1 to maintain

640 Turn VTUAV 1 towards WNW
and track towards Boat 2
15 Sec (...640); 7.1.2.1

522 Monitor images of Contact 4
recorded by UAV Op
25 Sec (...500); 7.3.5.2

562 Monitor discussion
12 Sec (...546); 9.2.1.7

652 Monitor approach to waypoint
to commence Rig of Boat 2
14 Sec (...640); 7.1.3

644 Advise UAV Op that Rig of
Boat 2 to commenced, 1 min
6 Sec (...640); 9.4.1.4

709 End Goal 546 ... Boat 3 is
classified using the ISAR
imagery from MALE UAV

650 Receive message and discuss
investigation of small boat
5 Sec (...640); 9.2.1.7

Part 2 — IP/PCT Scenario of UAV Operations — Page 40

Min 21–40 — Control of VTUAV and Mini UAV During Search for Terrorist Vessel

Ex Out	UAV Plt Up. Level Goals	Other Members of CP-140 Crew	Time Min/Sec
		566 (NAVCOM) Request MALE UAV use ISAR to classify Contact 3 16 Sec (...564)	14 4
			14 9
			14 10
		553 (NASO1) Analyse imagery and determine that image is Boat 3 18 Sec (...546)	14 13
			14 26
		554 (NASO1) Discuss analysis of ISAR imagery with UAV Op 7 Sec (...546)	14 28
	720 640 ... VTUAV 1 is approaching Boat 2 and preparing for EO Rig of boat		14 33
		558 (NASO1) Determine that Boat 3 is small with no containers 9 Sec (...546)	14 35
	721 End Goal 640 ... VTUAV 1 is approaching Boat 2 and preparing for EO Rig of boat		14 41
		559 (NASO1) Advise that Boat 3 is classified neutral, no threat 12 Sec (...546)	14 44
			14 48
			14 48
		647 (AC) Monitor message regarding EO Rig of Boat 2 6 Sec (...640)	14 48
			14 55
			14 56

Time	Other Units: ROC, CPF	Mini UAVs	VTUAV
Min/Sec			
15 1			
15 10			
15 24			
15 25			
15 33			
15 33			
15 38			
15 43			
15 44			
15 47			
15 55			
16 1			
16 1			

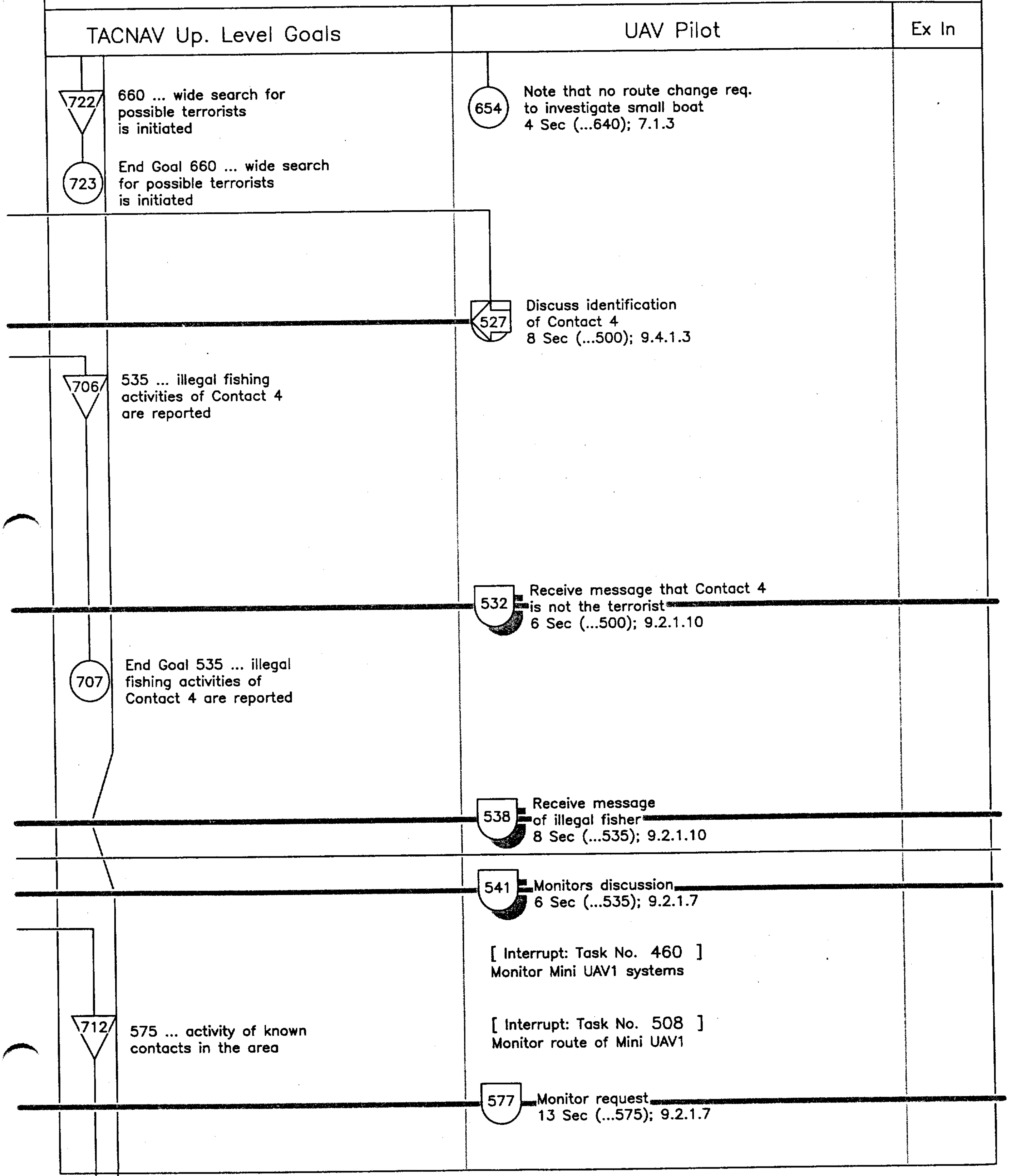
Part 2 — IP/PCT Scenario of UAV Operations — Page 42

Min 21–40 — Control of VTUAV and Mini UAV During Search for Terrorist Vessel

UAV Operator	UAV Op Up. Level Goals	TACNAV
521 Study boat mid–ships and bow structure for lethal UAV 10 Sec (...500); 7.3.5.2		660 Study surface plot for update on the progress of VTUAV 1 8 Sec (...660); 7.1.3
523 Identify Contact 4 using the ROC database 14 Sec (...500); 4.4.5		662 Plan to widen the search for terrorist vessels 15 Sec (...660); 6.4.4
		664 Commence resizing the area displayed on workstations 12 Sec (...660); 6.4.5
524 Discuss identification of Contact 4 8 Sec (...500); 9.4.1.3		525 Monitor discussion 8 Sec (...500); 9.2.1.7
535 Determine that boat is fishing illegally in the zone 14 Sec (...535); 4.4.9		
528 Conclude that Contact 4 is the "Catch Me if You Can" 5 Sec (...500); 4.4.5		
[Interrupt: Task No. 500] Conduct classification		
530 Advise crew that Contact 4 is not the terrorist 6 Sec (...500); 9.4.1.3		531 Receive message that Contact 4 is not the terrorist 6 Sec (...500); 9.2.1.10
	705 End Goal 500 ... identity of Contact 4 is determined using Mini UAV 1	
536 Advise crew of illegal fisher 8 Sec (...535); 9.4.1.3		537 Receive message of illegal fisher 8 Sec (...535); 9.2.1.10
543 Monitors discussion 6 Sec (...535); 9.2.1.7		540 Request that NAVCOM action on–line fishing violation report 6 Sec (...535); 9.3.1
544 Set Mini UAV1 to autonomous ops to record evidence 7 Sec (...535);7.3.2.6		
576 Monitor request 13 Sec (...575); 9.2.1.7		575 Request an update of Contact 3 & boats near Boat 3 (Cont. 5) 13 Sec (...575); 9.3.1

Part 2 Min 21–40 | IP/PCT Scenario of UAV Operations | Page 43

Control of VTUAV and Mini UAV During Search for Terrorist Vessel



Part 2 IP/PCT Scenario of UAV Operations Page 44

Min 21–40 Control of VTUAV and Mini UAV During Search for Terrorist Vessel

Ex Out	UAV Plt Up. Level Goals	Other Members of CP–140 Crew	Time Min/Sec
			15 1
			15 10
			15 24
			15 25
			15 33
			15 33
		533 (AC) Receive message that Contact 4 is not the terrorist 6 Sec (...500)	15 38
			15 43
			15 44
		539 (AC) Receive message of illegal fisher 8 Sec (...535)	15 47
		542 (NAVCOM) Reports that request will be actioned immediately 6 Sec (...535)	15 55
			16 1
		578 (NASO1) Receive request for radar update 13 Sec (...575)	16 1

Part 2 Min 21–40

IP/PCT Scenario of UAV Operations
Control of VTUAV and Mini UAV During Search for Terrorist Vessel

Time Min/Sec	Other Units: ROC, CPF	Mini UAVs	VTUAV
		[Interrupt: Task No. 758] Overfly Contact 4 and	
16 14		760 Commence autonomous operation to record evidence	
16 20	600 (CPF) Advise VTUAV 2 operating 30 nm South of VTUAV 1 16 Sec (...600)		
16 32			
16 36			
16 36			
16 39			
16 49			
17 9			
17 15			
17 20			
17 20	606 (ROC) Advise that ISAR imagery of Contact 3 is available 12 Sec (...606)		
17 29			
17 32			
17 38			

Part 2 IP/PCT Scenario of UAV Operations Page 46

Min 21–40 Control of VTUAV and Mini UAV During Search for Terrorist Vessel

UAV Operator	UAV Op Up. Level Goals	TACNAV
		601 Monitor message and record location on surface plot 16 Sec (...600); 9.2.2.3
		580 Receive radar update of surface plot 4 Sec (...575); 8.1.1
		582 Note progress of CP140 to vicinity of Boat 3 (Cont. 5) 3 Sec (...575); 8.9.6
		584 Note manoeuvring of Contact 4 12 Sec (...575); 2.5.2.1
		586 Review real–time video from Mini UAV1 10 Sec (...575); 7.3.5.2
		588 Review last 5 minutes of video data collected over Contact 4 20 Sec (...575); 7.3.8.1
		589 Note that illegal fishing was recorded for Contact 4 6 Sec (...575); 4.4.9
		590 Note that Contact 4 can be identified 4 Sec (...575); 4.4.10
	716 606 ... Contact 3 is classified and determined to be neutral	591 Note that fishers saw Mini UAV & covered fish with tarpaulin 10 Sec (...575); 7.3.5.2
		608 Monitors message 12 Sec (...606); 9.2.4
		592 Note that Mini UAV1 following Contact 4 as it heads South 13 Sec (...575); 7.3.3.5
		610 Request NAS01 download ISAR imagery, analyse and report 6 Sec (...606); 9.3.1

Part 2 IP/PCT Scenario of UAV Operations Page 47

Min 21–40 Control of VTUAV and Mini UAV During Search for Terrorist Vessel

TACNAV Up. Level Goals	UAV Pilot	Ex In
714 600 ... message regarding the location of the operation area for VTUAV 2		
715 End Goal 600 ... message regarding the location of the operation area for VTUAV 2		
718 630 ... MALE UAV is tasked to conduct ISAR imaging of Boat 2		

Ex Out	UAV Plt Up. Level Goals	Other Members of CP–140 Crew	Time Min/Sec
		579 (NASO1) Update Contact 3 and boats near Boat 3 (Cont. 5) 18 Sec (...575)	16 14
		602 (NAVCOM) Receive message 16 Sec (...600)	16 20
			16 32
			16 36
			16 36
			16 39
			16 49
			17 9
			17 15
			17 20
		607 (NAVCOM) Receives message 12 Sec (...606)	17 20
			17 29
		611 (NASO1) Receive request 6 Sec (...606)	17 32
		612 (NASO1) Download/extract ISAR imagery from ROC image server 14 Sec (...606)	17 38

Time Min/Sec	Other Units: ROC, CPF	Mini UAVs	VTUAV
17 38			
17 42			
17 50	633 (ROC) Receive request and advise imagery in 3 minutes 16 Sec (...630)		
17 51			
17 52			
18 0			
18 6			
18 10			
18 17			
18 22			

Part 2 IP/PCT Scenario of UAV Operations Page 50
Min 21–40 Control of VTUAV and Mini UAV During Search for Terrorist Vessel

UAV Operator	UAV Op Up. Level Goals	TACNAV
		630 Request that MALE UAV use ISAR to image Boat 2 12 Sec (...630); 9.3.1
		593 Review NAVCOM's on–line fishing violation report 12 Sec (...575); 9.4.2
635 Monitor request 16 Sec (...630); 9.2.1.7		634 Monitor request 16 Sec (...630); 9.2.1.7
617 Discuss analysis of ISAR imagery with NAS01 10 Sec (...606); 9.4.1.3		618 Monitor discussion 10 Sec (...606); 9.2.1.7
624 Monitor message and concur with findings, neutral class. 5 Sec (...606); 9.4.1.3		623 Receive message and advise no further investigation req. 5 Sec (...606); 9.4.1.3
	717 End Goal 606 ... Contact 3 is classified and determined to be neutral	960 Network Task End of Part 2

TACNAV Up. Level Goals	UAV Pilot	Ex In
	636 Monitor request 16 Sec (...630); 9.2.1.7	
713 End Goal 575 ... activity of known contacts in the area		
719 End Goal 630 ... MALE UAV is tasked to conduct ISAR imaging of Boat 2		
	625 Monitor discussion 5 Sec (...606); 9.2.1.7	
	[Interrupt: Task No. 652] Monitor approach to waypoint	

Part 2 — IP/PCT Scenario of UAV Operations — Page 52

Min 21–40 — Control of VTUAV and Mini UAV During Search for Terrorist Vessel

Ex Out	UAV Plt Up. Level Goals	Other Members of CP–140 Crew	Time Min/Sec
		631 (NAVCOM) Receive request 12 Sec (...630)	17 38
			17 42
		632 (NAVCOM) Request MALE UAV use ISAR to classify Boat 2 16 Sec (...630)	17 50
			17 51
		614 (NAS01) Analyse imagery and determine that image is fisher 8 Sec (...606)	17 52
		616 (NAS01) Discuss analysis of ISAR imagery with UAV Op 10 Sec (...606)	18 0
			18 6
		620 (NAS01) Determine that Cont. 3 is trawler with no containers 7 Sec (...606)	18 10
		622 (NAS01) Advise that Boat 3 is classified neutral, no threat 5 Sec (...606)	18 17
			18 22

The following OSD represents in graphical form Part Three of the Composite Scenario, which is shown in Figure D-4.

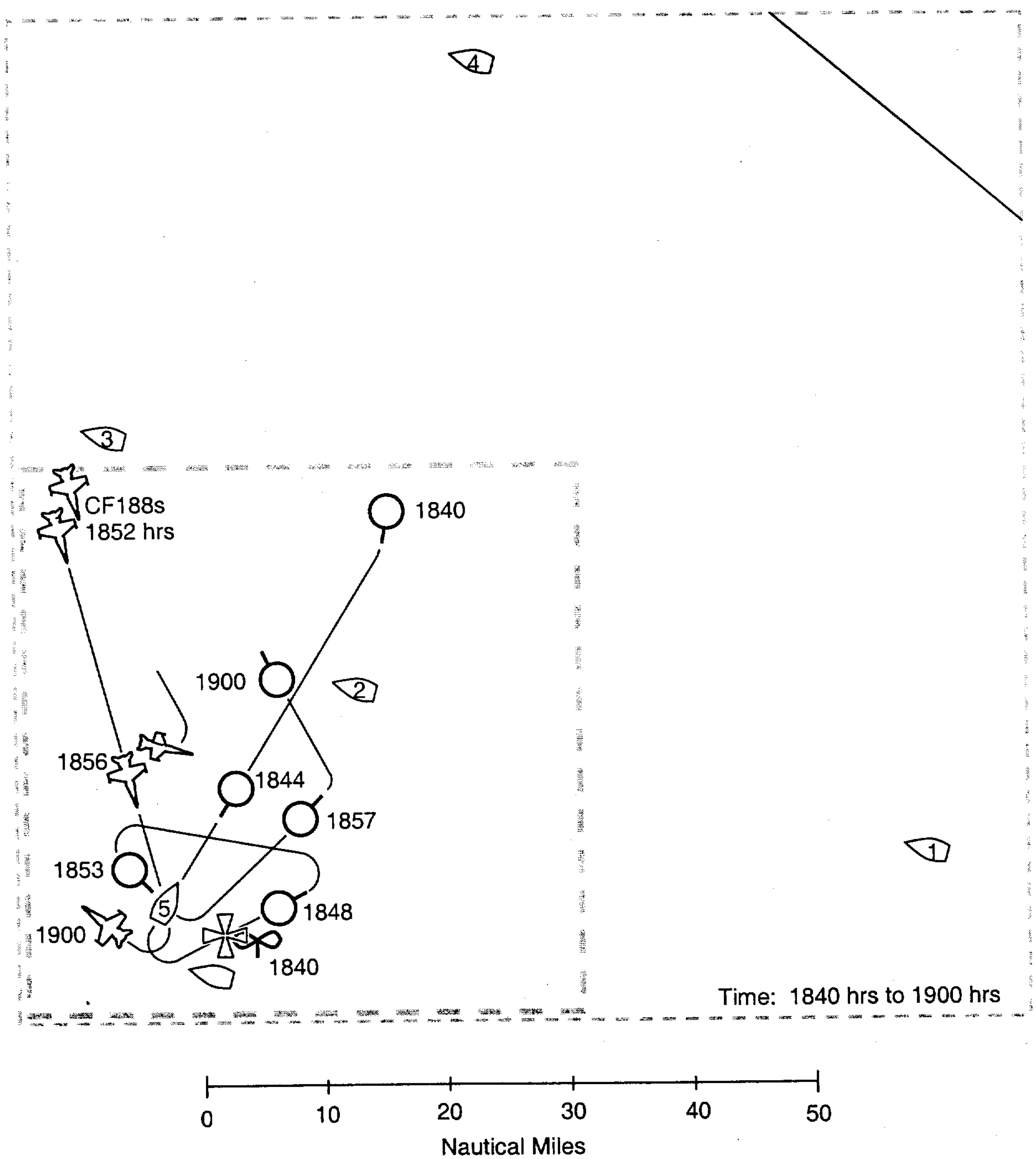


Figure D-4 Detailed Mission Scenario – Part 3

Part 3 IP/PCT Scenario of UAV Operations involving IAI Page 1
Min 41–60 Control of Multiple UAVs During Attack on Terrorist Vessel

Time Min/Sec	Other Units: ROC, CPF	Mini UAVs	VTUAV
0 0		599 Maintain video recording of Contact 4 as it moves South	600 Maintain heading towards "turn–in" waypoint
0 0			
0 0			
0 3			
0 7			
			[Interrupt: Task No. 600] Maintain heading towards
0 20			601 At waypoint turn and track towards Boat 2
0 37			602 Track at 800 ft towards Boat 2
0 42			
0 52			
0 53			
1 10			
1 10	148 (ROC) ISAR imagery available on secure web site 15 Sec (...148)		
1 17			603 Stop transmitting video and data

Time and Date of Data File: 17:00 12 Jun 04

Part 3 — IP/PCT Scenario of UAV Operations involving IAI — Page 2

Min 41–60 — Control of Multiple UAVs During Attack on Terrorist Vessel

UAV Operator	UAV Op Up. Level Goals	TACNAV
		900 Network Tasks Start 1840 hrs
140 Optimize EO systems for the environmental conditions 6 Sec (...132); 7.1.4.1		120 Develop contingence plans to expand or refine the search 30 Sec (...120); 6.8.1
		902 70 Sec
		136 Receive recommendation to climb to 15,000 ft and conc 4 Sec (...130); 9.4.1.5
		122 Plan the use of the MALE UAV 9 Sec (...120); 7.2.1
142 Note that the fishing boat at 3 miles back is visible 4 Sec (...132); 7.1.5.2		
143 Search for Contact 5 11 Sec (...132); 7.1.5.1		123 Plan the use of the CP140 14 Sec (...120); 8.1.3
145 Photo fishing boat and observe fishers pointing at VTUAV Cont. (...132); 7.1.5.5		
126 Monitor discussion regarding the tactical situation 35 Sec (...120); 9.2.1.10		124 Discuss the tactical situation with the AC 35 Sec (...120); 9.4.1.5
		149 Monitor transmission 15 Sec (...148); 9.2.4
[Interrupt: Task No. 145] Photo fishing boat and observe	718 164 ... operational viability of VTUAV 1	

Part 3 — IP/PCT Scenario of UAV Operations involving IAI — Page 3

Min 41–60 — Control of Multiple UAVs During Attack on Terrorist Vessel

TACNAV Up. Level Goals	UAV Pilot	Ex In
710 — 120 ... plan to utilize available assets is developed	132 — Maintain VTUAV flight towards the "turn-in" waypoint Cont. (...132); 7.1.3	
712 — 130 ... CP140 is en route Boat 2	904 — 15 Sec	
	134 — Study the route to be flown to investigate Boat 2 6 Sec (...132); 7.1.1.1	
	135 — Conduct a systems check of the VTUAV systems 9 Sec (...132); 7.1.9.4	
	[Interrupt: Task No. 132] Maintain VTUAV flight towards	
	137 — At waypoint turn VTUAV 1 to track towards Boat 2 22 Sec (...132); 7.1.2.1	
	910 — 40 Sec	
713 — End Goal 130 ... CP140 is en route Boat 2	138 — Maintain track at 800 ft to wpt to start Rig of Boat 2 Cont. (...132); 7.1.3	
	127 — Monitor discussion regarding the tactical situation 35 Sec (...120); 9.2.1.10	
716 — 148 ... ISAR imagery of Boat 2 is analysed		
	[Interrupt: Task No. 138] Maintain track at 800 ft to	

Part 3 IP/PCT Scenario of UAV Operations involving IAI Page 4
Min 41–60 Control of Multiple UAVs During Attack on Terrorist Vessel

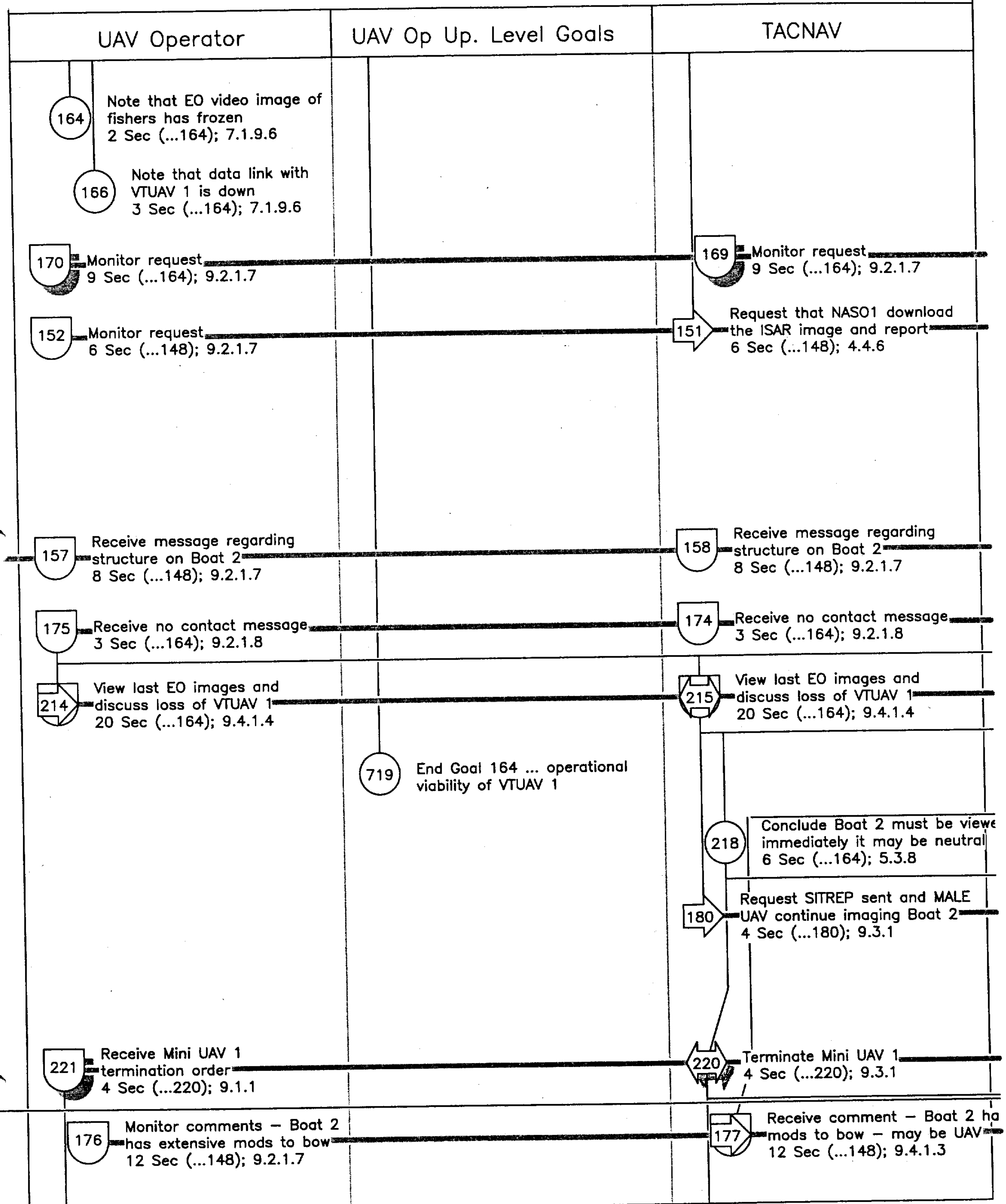
Ex Out	UAV Plt Up. Level Goals	Other Members of CP–140 Crew	Time Min/Sec
	714 132 ... VTUAV 1 is approaching Boat 2	130 (AC) Maintain flight en route Boat 2 Cont. (...130)	0 0
		131 (AC) Note weather in the area is scattered, visibility 5 nm 3 Sec (...130)	0 0
			0 0
		133 (AC) Recommend climb to 15,000 because weather is clearing 4 Sec (...130)	0 3
		139 (AC) Climb to 15,000 ft to avoid IR missiles 180 Sec (...130)	0 7
			0 20
			0 37
			0 42
			0 52
		125 (AC) Discuss the tactical situation with the TACNAV 35 Sec (...120)	0 53
			1 10
		150 (NAVCOM) Receive message that ISAR imagery of Boat 2 ready 15 Sec (...148)	1 10
	715 End Goal 132 ... VTUAV 1 is approaching Boat 2		1 17

Part 3 Min 41–60	IP/PCT Scenario of UAV Operations involving IAI Control of Multiple UAVs During Attack on Terrorist Vessel	Page 5

Time Min/Sec	Other Units: ROC, CPF	Mini UAVs	VTUAV
1 17			
1 17			
1 19			
1 25	908 7 Sec		
1 29			
1 31			
1 32	155 (ROC) Advise that the ISAR indicates structure on boat 8 Sec (...148)		
1 42			
1 45			
2 0			
2 5			
2 5			
2 10			
2 11			
2 12			

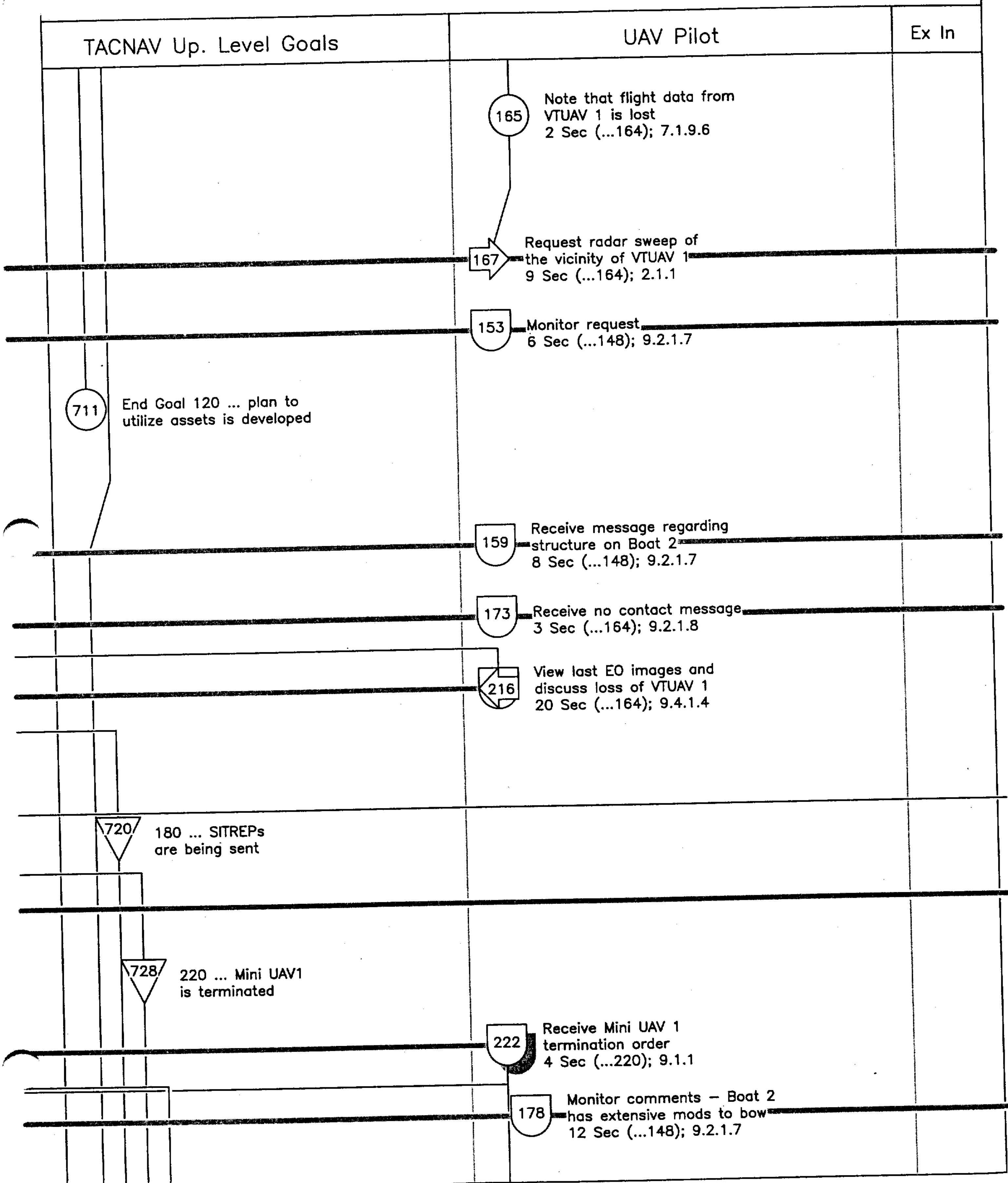
Part 3 IP/PCT Scenario of UAV Operations involving IAI Page 6

Min 41–60 Control of Multiple UAVs During Attack on Terrorist Vessel



Part 3 IP/PCT Scenario of UAV Operations involving IAI Page 7

Min 41–60 Control of Multiple UAVs During Attack on Terrorist Vessel



Part 3 Min 41–60	IP/PCT Scenario of UAV Operations involving IAI Control of Multiple UAVs During Attack on Terrorist Vessel	Page 8

Ex Out	UAV Plt Up. Level Goals	Other Members of CP–140 Crew	Time Min/Sec
			1 17
			1 17
		168 (NASO1) Receive request for radar sweep 9 Sec (...164)	1 19
		154 (NAVO1)Receive request to download ISAR images & report 6 Sec (...148)	1 25
		171 (NASO1) Switch radar to Air–to –Air and search for VTUAV 1 5 Sec (...164)	1 29
		160 (NASO1) Download ISAR imagery of Boat 2 27 Sec (...148)	1 31
		156 (NAVCOM) Receive message regarding structure on Boat 2 8 Sec (...148)	1 32
		172 (NASO1) Report no contact with VTUAV 1 3 Sec (...164)	1 42
			1 45
		161 (NASO1) Analyse ISAR imagery 14 Sec (...148)	2 0
			2 5
		181 (NAVCOM) Receive request 4 Sec (...180)	2 5
		182 (NAVCOM) Prepare SITREP 9 Sec (...180)	2 10
			2 11
		179 (NASO1) Boat 2 has extensive mods to bow – may be UAV 12 Sec (...148)	2 12

Part 3 IP/PCT Scenario of UAV Operations involving IAI

Min 41–60 Control of Multiple UAVs During Attack on Terrorist Vessel

Time Min/Sec	Other Units: ROC, CPF	Mini UAVs	VTUAV
2 15		[Interrupt: Task No. 599] Maintain video recording of	
2 15		604 Mini UAV 1 climbs to 1000 ft and dives into the sea	
2 18	186 (ROC) Receive message 10 Sec (...180)		
2 24			
2 24	912 90 Sec		
2 28	189 (MOC) Receive message 10 Sec (...180)		
2 29			
2 37	911 30 Sec		
2 41			
2 53			
2 56			
2 56			
3 5			
3 8	203 (MOC) CF188s have been tasked to close at maximum speed 11 Sec (...203)		
3 16			

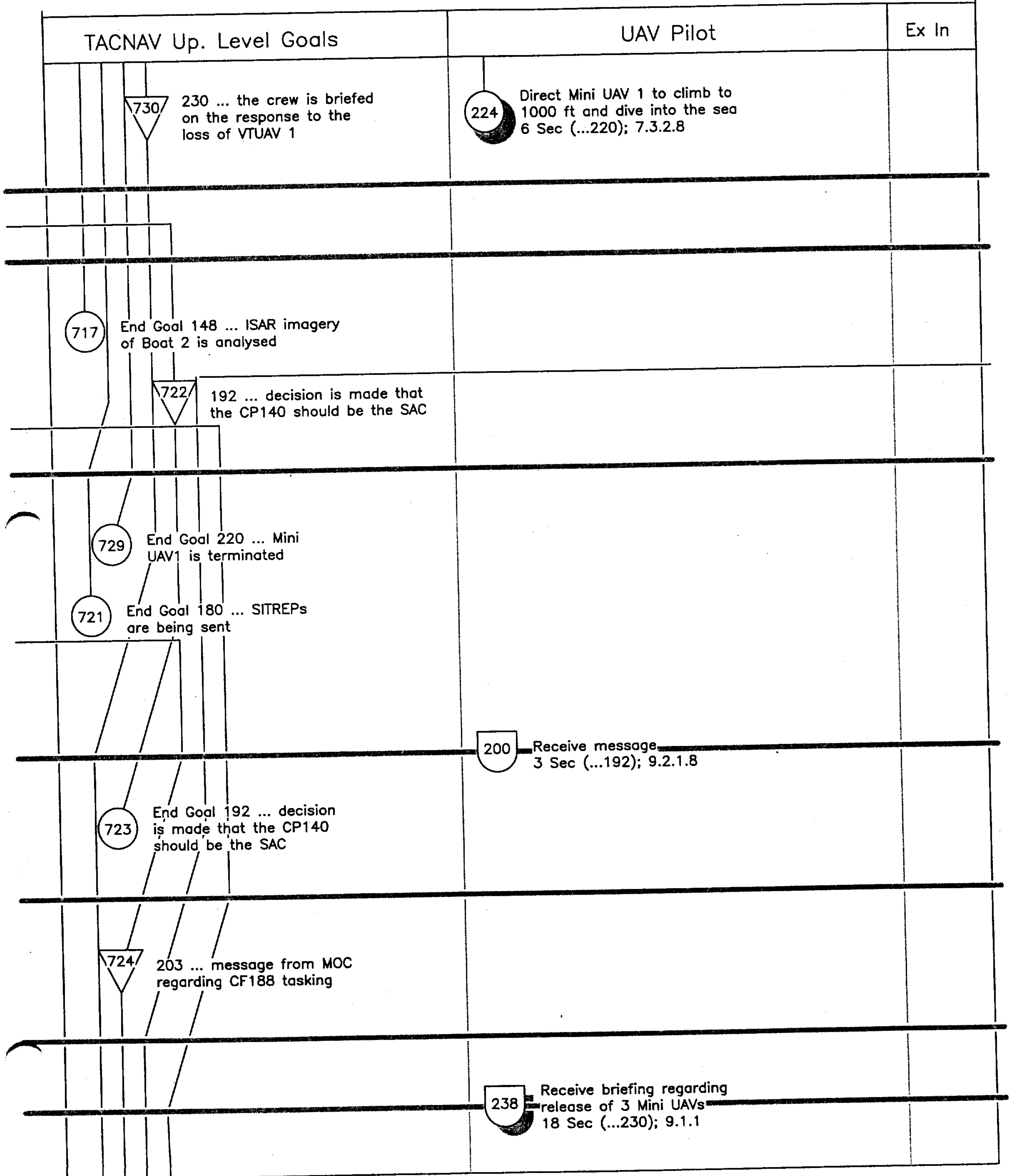
Part 3 — IP/PCT Scenario of UAV Operations involving IAI — Page 10

Min 41–60 — Control of Multiple UAVs During Attack on Terrorist Vessel

UAV Operator	UAV Op Up. Level Goals	TACNAV
223 Electronically stow all Mini UAV 1 files 14 Sec (...220); 7.3.7.5		
		230 Request speed increase to VNE, home Boat 2 at 4000 ft 9 Sec (...230); 9.3.1
		185 Monitor message 10 Sec (...180); 9.2.1.7
		192 Assess command and control situation 12 Sec (...192); 3.5.1
		188 Monitor message 10 Sec (...180); 9.2.1.7
		194 Determine location of CPF and MH 5 Sec (...192); 3.1.1
		196 Determine that CP140 should be SAC 12 Sec (...192); 3.5.2
199 Receive message 3 Sec (...192); 9.2.1.8		198 Advise crew that the CP140 has assumed the role of SAC 3 Sec (...192); 9.4.1.5
		232 Advise all radio transmissions to be secure, full EW policies 5 Sec (...230); 9.3.4
		235 Plan investigation of Boat 2 using Mini UAVs 15 Sec (...230); 7.3.1.2
		204 Receive message regarding CF188s 11 Sec (...203); 9.4.3
237 Receive briefing regarding release of 3 Mini UAVs 18 Sec (...230); 9.1.1		236 Brief crew: over-fly boat drop 3 Mini UAVs then orbit 4000 ft 18 Sec (...230); 7.3.1.10

Part 3 IP/PCT Scenario of UAV Operations involving IAI | Page 11

Min 41–60 Control of Multiple UAVs During Attack on Terrorist Vessel



Part 3 IP/PCT Scenario of UAV Operations involving IAI — Page 12

Min 41–60 Control of Multiple UAVs During Attack on Terrorist Vessel

Ex Out	UAV Plt Up. Level Goals	Other Members of CP–140 Crew	Time Min/Sec
			2 15
		231 (AC) Receive request to increase speed and home boat 9 Sec (...230)	2 15
		184 (NAVCOM) Provide SITREP and request more images of Boat 2 10 Sec (...180)	2 18
		915 65 Sec	2 24
			2 24
		187 (NAVCOM) Provide SITREP to MOC 10 Sec (...180)	2 28
			2 29
			2 37
			2 41
		201 (CP140 Crew) Receive message 3 Sec (...192)	2 53
			2 56
		233 (NAVCOM) Receive direction full EW policies 5 Sec (...230)	2 56
			3 5
		205 (NAVCOM) Receive message regarding CF188s – new freqs 11 Sec (...203)	3 8
		239 (Crew) Receive briefing about release of 3 Mini UAVs 18 Sec (...230)	3 16

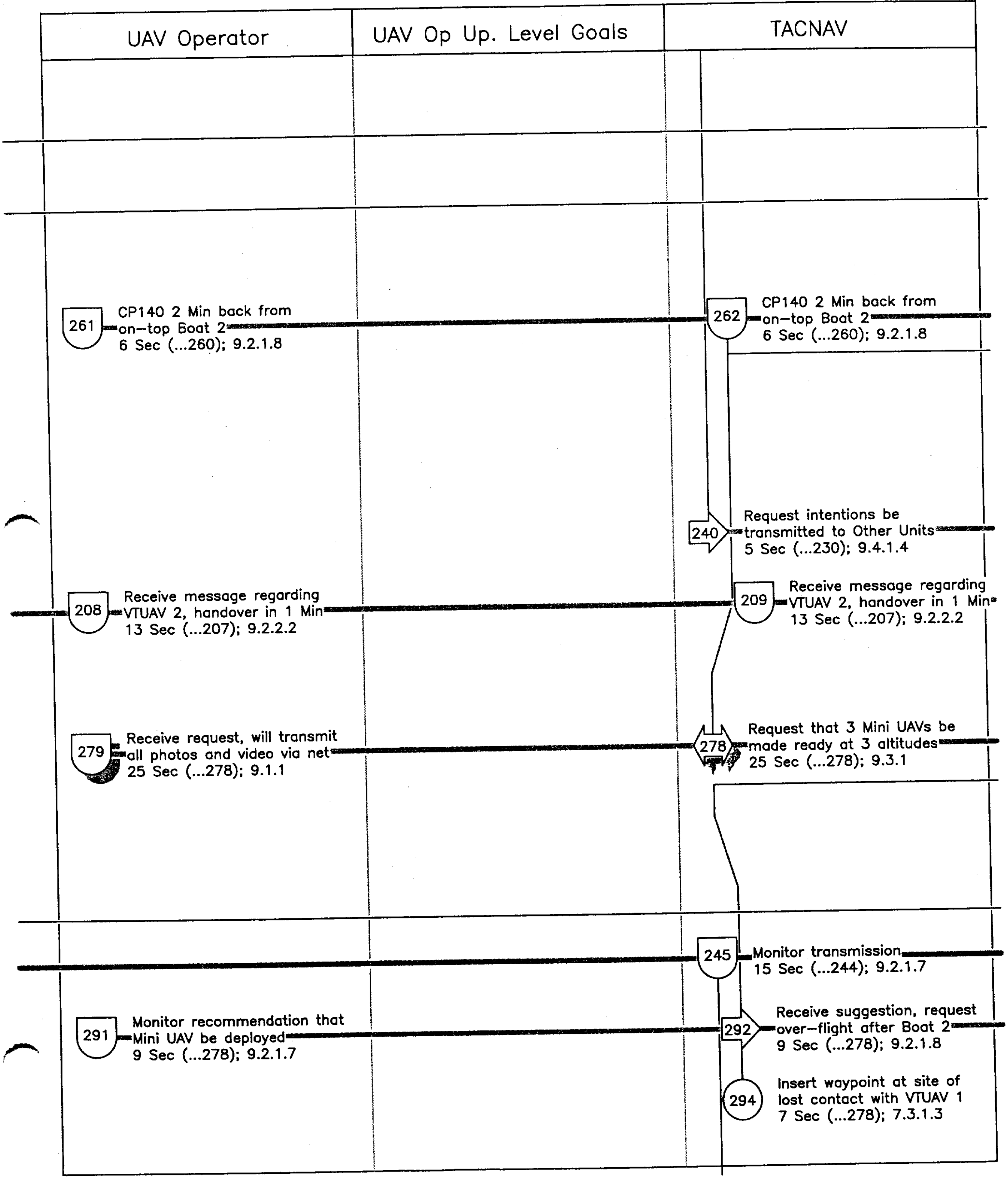
Part 3 — IP/PCT Scenario of UAV Operations involving IAI — Page 13

Min 41–60 — Control of Multiple UAVs During Attack on Terrorist Vessel

Time	Other Units: ROC, CPF	Mini UAVs	VTUAV
Min/Sec			
3 19	909 — 15 Sec		
3 23	922 — 270 Sec		
3 29			
3 29			
3 31			
3 34			
3 34			
3 34	207 — (CPF) Vectoring VTUAV 2 towards Boat 2, handover 1 Min 13 Sec (...207)		
3 35			
3 35			
3 40			
3 47	914 — 60 Sec		
3 58	244 — (ROC) New Boat 2 ISAR imagery available on secure web site 15 Sec (...244)		
4 0			
4 9			

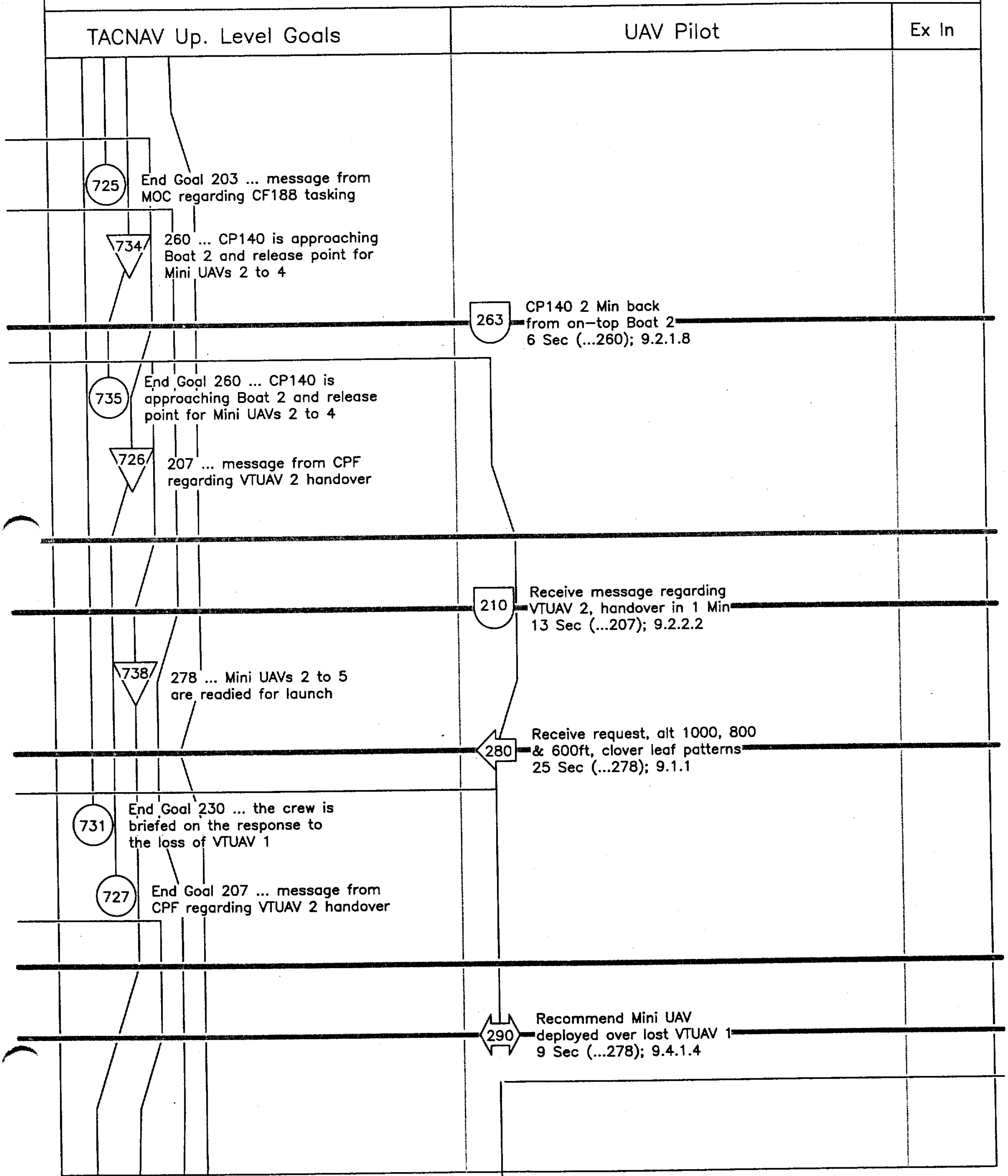
Part 3 — IP/PCT Scenario of UAV Operations involving IAI — Page 14

Min 41–60 — Control of Multiple UAVs During Attack on Terrorist Vessel



Part 3 — IP/PCT Scenario of UAV Operations involving IAI — Page 15

Min 41–60 — Control of Multiple UAVs During Attack on Terrorist Vessel



Part 3 — Min 41–60 — IP/PCT Scenario of UAV Operations involving IAI — Control of Multiple UAVs During Attack on Terrorist Vessel — Page 16

Ex Out	UAV Plt Up. Level Goals	Other Members of CP–140 Crew	Time Min/Sec
		206 (NAVCOM) Sets radio for CF188 frequencies 4 Sec (...203)	3 19
			3 23
			3 29
		260 (AC) CP140 2 Min back from on–top Boat 2 6 Sec (...260)	3 29
			3 31
			3 34
		241 (NAVCOM) Receive request to transmitted intentions 5 Sec (...230)	3 34
		211 (NAVCOM) Receive message regarding VTUAV 2 & handover 13 Sec (...207)	3 34
			3 35
		281 (Ordnance) Receive request to load Mini UAVs (No 2, 3 & 4) 25 Sec (...278)	3 35
			3 40
			3 47
		246 (NAVCOM) Receive message that ISAR imagery of Boat 2 ready 15 Sec (...244)	3 58
		293 (AC) Receive request for over–flight. of lost VTUAV 1 9 Sec (...278)	4 0
		300 (NAS01) Finds VTUAV 1 wreckage on radar and plots position 12 Sec (...278)	4 9

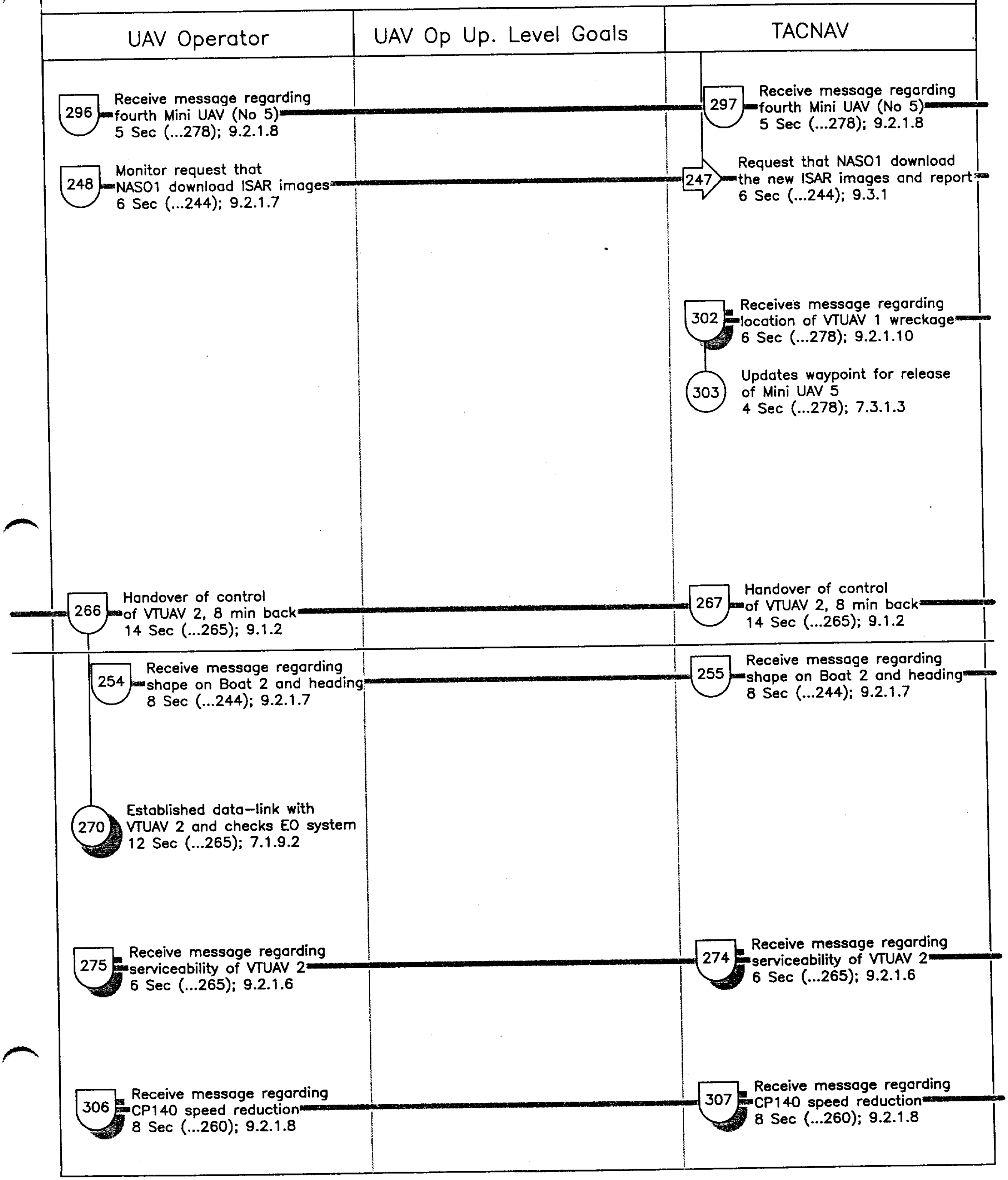
Part 3 — IP/PCT Scenario of UAV Operations involving IAI — Page 17

Min 41–60 — Control of Multiple UAVs During Attack on Terrorist Vessel

Time Min/Sec	Other Units: ROC, CPF	Mini UAVs	VTUAV
4 9			
4 13			
4 21			
4 27			
4 31			
4 46			
4 47	265 (CPF) Handover of control of VTUAV 2, 8 min back 14 Sec (...265)		
4 52			
5 1			605 CP140 UAV Crew take control of VTUAV2 and check systems
5 19			606 Heading maintained towards the location of Boat 2
5 19			
5 25			
6 47			

Part 3 IP/PCT Scenario of UAV Operations involving IAI Page 18

Min 41–60 Control of Multiple UAVs During Attack on Terrorist Vessel



Part 3 IP/PCT Scenario of UAV Operations involving IAI Page 19

Min 41–60 Control of Multiple UAVs During Attack on Terrorist Vessel

TACNAV Up. Level Goals	UAV Pilot	Ex In
	298 Advise will set search height of Mini UAV 5 to 600 ft 5 Sec (...278); 9.4.1.4	
	249 Monitor request that NAS01 download ISAR images 6 Sec (...244); 9.2.1.7	
739 End Goal 278 ... Mini UAVs 2 to 5 are readied for launch		
736 265 ... handover of VTUAV 2 is completed		
	268 Handover of control of VTUAV 2, 8 min back 14 Sec (...265); 9.1.2	
	256 Receive message regarding shape on Boat 2 and heading 8 Sec (...244); 9.2.1.7	
	271 Established flight control of VTUAV 2 and checks all system 18 Sec (...265); 7.1.9.2	
	272 Monitor VTUAV 2 on heading to the location of Boat 2 Cont. (...265); 7.1.3	
	273 Advises that VTUAV 2 is serviceable and ready, 2500 ft 6 Sec (...265); 9.4.1.4	
737 End Goal 265 ... handover of VTUAV 2 is completed		
	308 Receive message regarding CP140 speed reduction 8 Sec (...260); 9.2.1.8	

Part 3 IP/PCT Scenario of UAV Operations involving IAI Page 20
Min 41–60 Control of Multiple UAVs During Attack on Terrorist Vessel

Ex Out	UAV Plt Up. Level Goals	Other Members of CP–140 Crew	Time Min/Sec
		295 (Ordnance) Will prepare a fourth Mini UAV (No 5) 5 Sec (...278)	4 9
		250 (NASO1) Receive request to download ISAR images & report 6 Sec (...244)	4 13
		913 7 Sec	
		301 (NASO1) Advises wreckage of VTUAV 1 found and plotted 6 Sec (...278)	4 21
		251 (NASO1) Download ISAR imagery of Boat 2 18 Sec (...244)	4 27
			4 31
		252 (NASO1) Analyse ISAR imagery 8 Sec (...244)	4 46
		269 (NAVCOM) Accepts control of VTUAV 2 14 Sec (...265)	4 47
		253 (NASO1) ISAR shows container shape on bow – heading NNE 8 Sec (...244)	4 52
			5 1
		916 90 Sec	5 19
			5 19
			5 25
		305 (AC) Advises CP140 slowing for release of Mini UAVs 2, 3 & 4 8 Sec (...260)	6 47

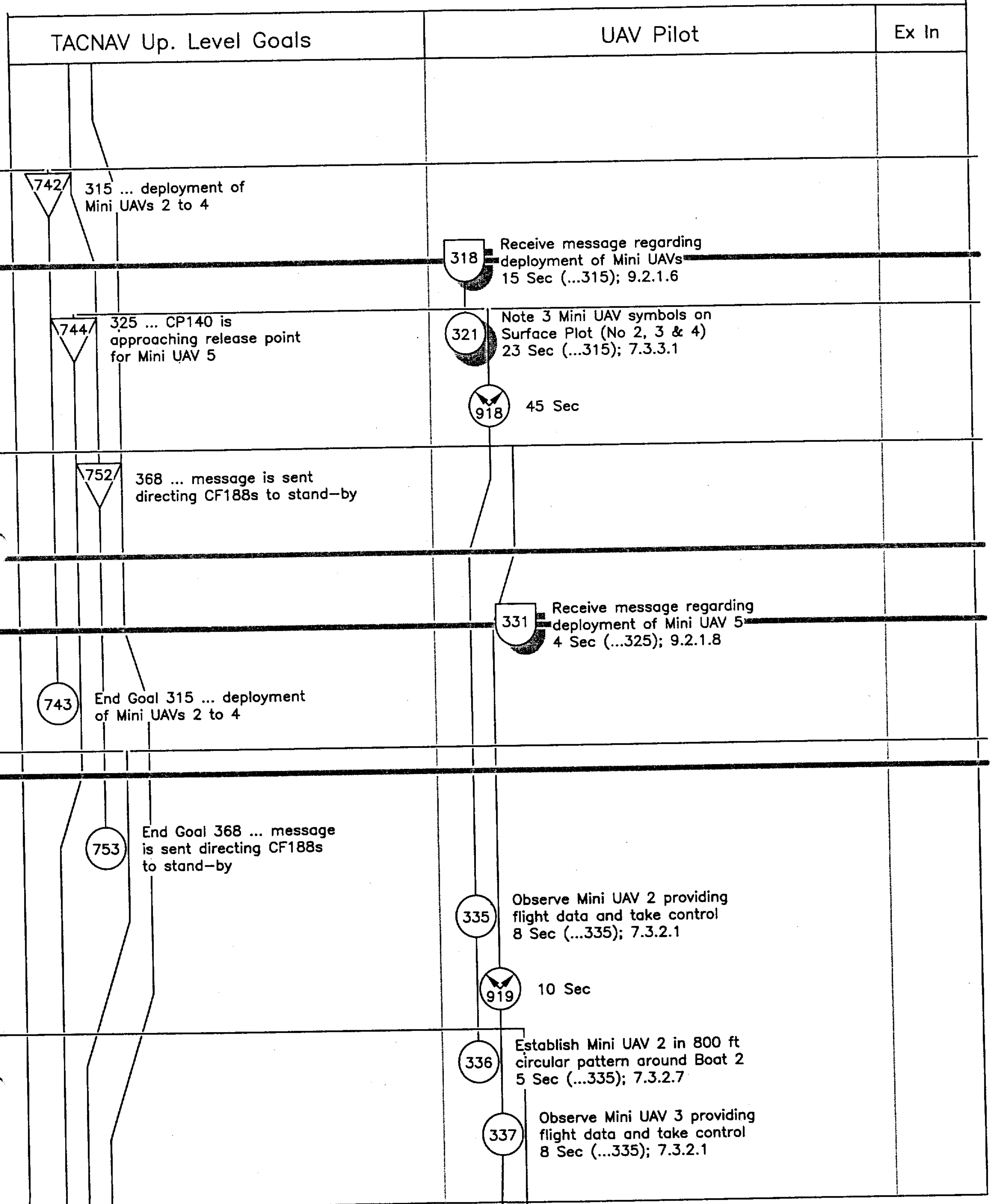
Part 3 IP/PCT Scenario of UAV Operations involving IAI Page 21
Min 41–60 Control of Multiple UAVs During Attack on Terrorist Vessel

Time Min/Sec	Other Units: ROC, CPF	Mini UAVs	VTUAV
7 17		607 Mini UAVs 2, 3 & 4 released over Boat 2	
7 17			
7 32			
7 32			
7 49			
7 49	368 (Hornets) Advise 10 min back with precision guided weapons 10 Sec (...368)		
7 49			
7 55			
7 59	372 (Hornets) Receive stand-by for visual confirmation of threat 6 Sec (...368)		
8 5			
8 17		608 Mini UAV 2 provides flight data	
8 25		609 Mini UAV 2 establishes 800 ft circular pattern around Boat 2	
8 26		610 Mini UAV 3 provides flight data	
8 27			

Part 3 IP/PCT Scenario of UAV Operations involving IAI Page 22
Min 41–60 Control of Multiple UAVs During Attack on Terrorist Vessel

UAV Operator	UAV Op Up. Level Goals	TACNAV
316 Receive message regarding deployment of Mini UAVs 15 Sec (...315); 9.2.1.6		317 Receive message regarding deployment of Mini UAVs 15 Sec (...315); 9.2.1.6
320 Note 3 Mini UAV symbols on Surface Plot (No 2, 3 & 4) 23 Sec (...315); 7.3.3.1		319 Note 3 Mini UAV symbols on Surface Plot (No 2, 3 & 4) 23 Sec (...315); 7.3.3.1
		369 Receive message that Hornets are 10 minutes back with PGWs 10 Sec (...368); 9.2.2
329 Receive message regarding deployment of Mini UAV 5 4 Sec (...325); 9.2.1.8		330 Receive message regarding deployment of Mini UAV 5 4 Sec (...325); 9.2.1.8
		371 Roger, stand–by for visual confirmation of threat 6 Sec (...368); 9.1.1
345 Note EO video from Mini UAV 2 and optimize image 10 Sec (...335); 7.3.4.1		
346 Note EO video from Mini UAV 3 and optimize image 10 Sec (...335); 7.3.4.1		

Part 3 IP/PCT Scenario of UAV Operations involving IAI Page 23
Min 41–60 Control of Multiple UAVs During Attack on Terrorist Vessel



Part 3 | IP/PCT Scenario of UAV Operations involving IAI | Page 24

Min 41–60 | Control of Multiple UAVs During Attack on Terrorist Vessel

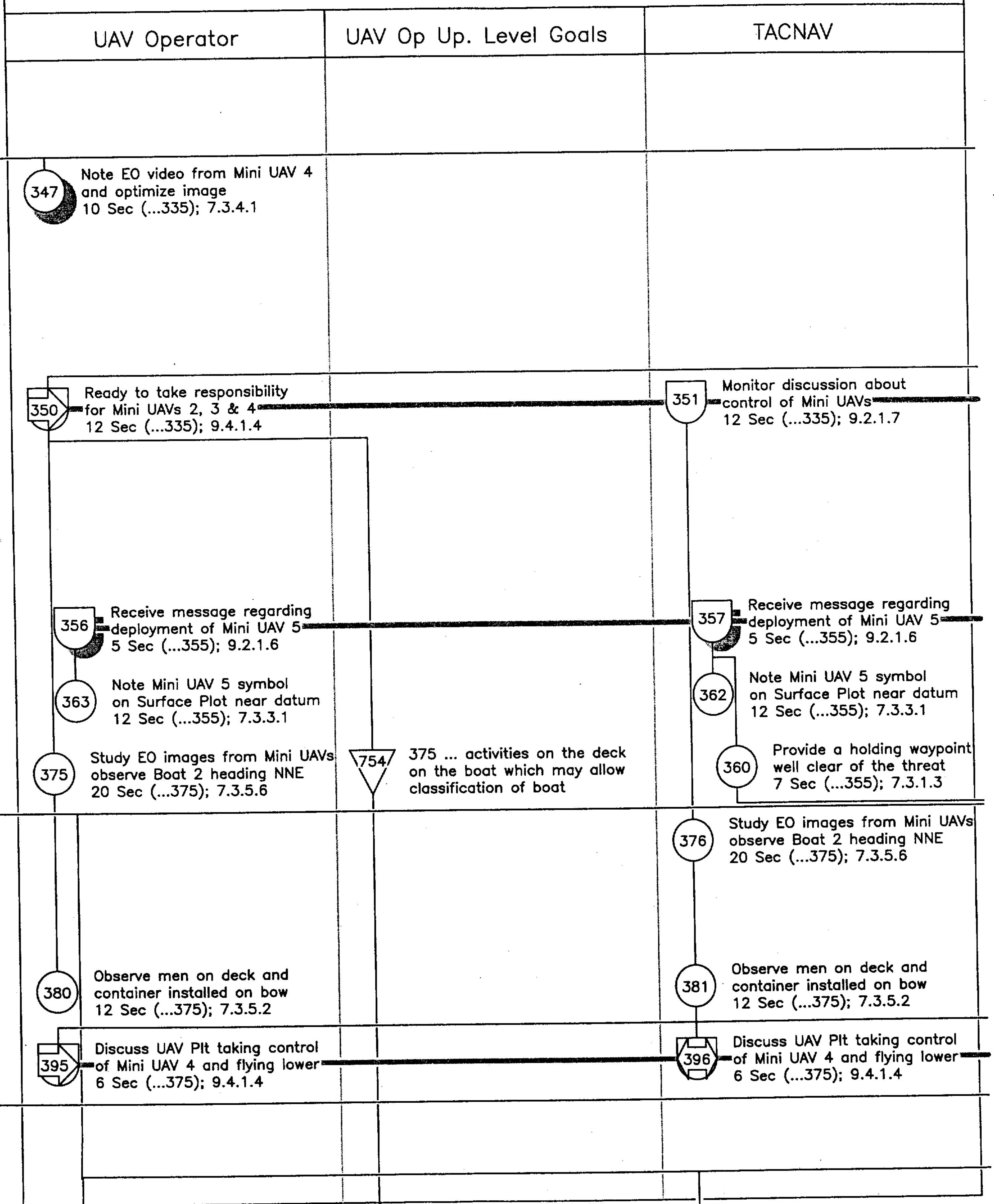
Ex Out	UAV Plt Up. Level Goals	Other Members of CP–140 Crew	Time Min/Sec
		917 22 Sec	
			7 17
		315 (AC) Advise Mini UAVs 2, 3 & 4 released over Boat 2 15 Sec (...315)	7 17
		[Interrupt: Task No. 130] (AC) Maintain flight	7 32
		325 (AC) Turn CP140 to waypoint for the release of Mini UAV 5 17 Sec (...325)	7 32
		326 (AC) Maintain level flight to waypoint at 15,000 ft Cont. (...325)	7 49
		370 (NAVCOM) Receive message that Hornets are 10 minutes back 10 Sec (...368)	7 49
		328 (AC) Advise 1 min back from release of Mini UAV 5 4 Sec (...325)	7 49
		921 60 Sec	7 55
		373 (NAVCOM) Monitor message stand–by for visual confirm. 6 Sec (...368)	7 59
			8 5
	746 335 ... Mini UAVs 2 to 4 are serviceable		8 17
			8 25
			8 26
			8 27

Part 3 Min 41–60	IP/PCT Scenario of UAV Operations involving IAI Control of Multiple UAVs During Attack on Terrorist Vessel	Page 25

Time Min/Sec	Other Units: ROC, CPF	Mini UAVs	VTUAV
8 35		611 Mini UAV 3 establishes 400 ft cloverleaf around Boat 2	
8 36		612 Mini UAV 4 provides flight data	
8 37			
8 45		613 Mini UAV 4 establishes 200 ft cloverleaf around Boat 2	
8 50			
8 53		614 Mini UAV 5 released over VTUAV 1 datum	
8 53			
8 53			
8 58			
9 1			
9 3			
9 7			
9 22			
9 34			
9 40		[Interrupt: Task No. 613] Mini UAV 4 establishes 200 ft	

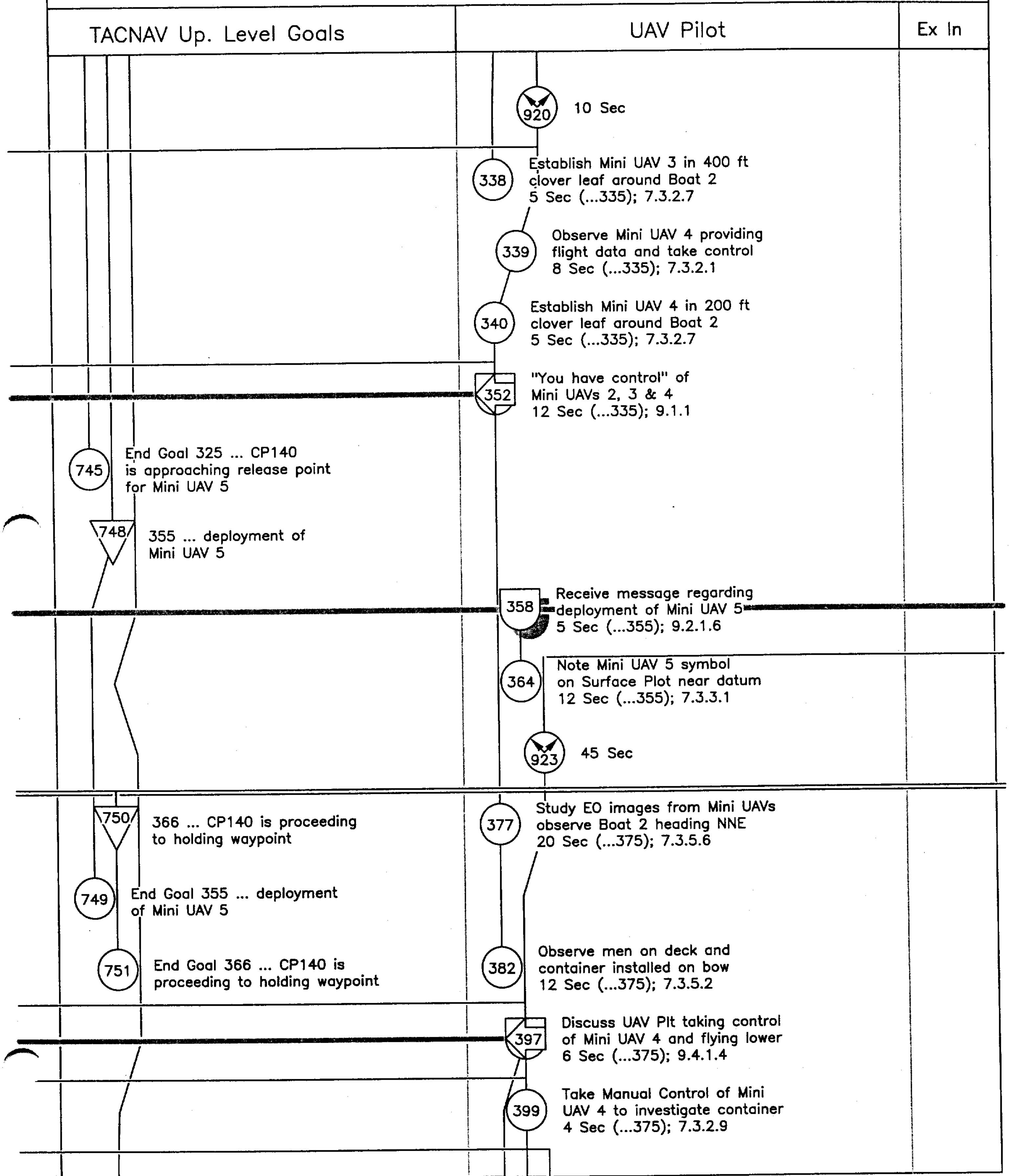
Part 3 — IP/PCT Scenario of UAV Operations involving IAI — Page 26

Min 41–60 — Control of Multiple UAVs During Attack on Terrorist Vessel



Part 3 Min 41–60

IP/PCT Scenario of UAV Operations involving IAI Control of Multiple UAVs During Attack on Terrorist Vessel



Part 3 | IP/PCT Scenario of UAV Operations involving IAI | Page 28
Min 41–60 | Control of Multiple UAVs During Attack on Terrorist Vessel

Ex Out	UAV Plt Up. Level Goals	Other Members of CP–140 Crew	Time Min/Sec
			8 35
			8 36
			8 37
			8 45
			8 50
			8 53
			8 53
		355 (AC) Advise Mini UAV 5 released over VTUAV 1 datum 5 Sec (...355)	8 53
			8 58
	747 End Goal 335 ... Mini UAVs 2 to 4 are serviceable		9 1
		[Interrupt: Task No. 326] (AC) Maintain level flight to	9 3
		366 (AC) Turn CP140 to waypoint 11 Sec (...366)	9 7
		367 (AC) Maintain level flight to waypoint at 15,000 ft 120 Sec (...366)	9 22
			9 34
			9 40

Part 3 Min 41–60	IP/PCT Scenario of UAV Operations involving IAI Control of Multiple UAVs During Attack on Terrorist Vessel		Page 29

Time Min/Sec	Other Units: ROC, CPF	Mini UAVs	VTUAV
9 42		615 UAV Pilot controls Mini UAV 4 to investigate container	
9 44		616 Mini UAV 5 provides flight data	
9 44		618 Mini UAV 4 conducts low pass and manoeuvring about Boat 2	
9 52		617 Mini UAV 5 establishes 800 ft circular pattern at VTUAV 1	
9 52			
9 56			
9 56			
9 56			
9 57			
10 8			
10 8			
10 17			
10 23			
10 23			
10 29		[Interrupt: Task No. 618] Mini UAV 4 conducts low pass	

Part 3 — IP/PCT Scenario of UAV Operations involving IAI — Page 30
Min 41–60 — Control of Multiple UAVs During Attack on Terrorist Vessel

UAV Operator	UAV Op Up. Level Goals	TACNAV
388 Note EO video from Mini UAV 5 and optimize image 10 Sec (...385); 7.3.4.1		
402 Observe JATO UAV mounted in a container, men removing covers 8 Sec (...375); 7.3.5.2		403 Observe JATO UAV mounted in a container, men removing covers 8 Sec (...375); 7.3.5.2
405 Observe second container which may be second Lethal UAV 4 Sec (...375); 7.3.5.2		406 Observe second container which may be second Lethal UAV 4 Sec (...375); 7.3.5.2
	758 410 ... classification of the terrorist vessel is completed	
410 Discuss finding of the Lethal UAV, conclude terrorist found 12 Sec (...410); 9.4.1.3		411 Discuss finding of the Lethal UAV, conclude terrorist found 12 Sec (...410); 9.4.1.3
389 Ready to take responsibility for Mini UAV 5 12 Sec (...385); 9.4.1.4		390 Monitor discussion about control of Mini UAV 5 12 Sec (...385); 9.2.1.7
	755 End Goal 375 ... activities on the boat which may allow classification of boat	
392 Verify Mini UAV 5 recording video of downed VTUAV 1 9 Sec (... 385); 7.3.5.9		414 Conclude Lethal UAV is being readied for launch 6 Sec (...410); 5.3.1
416 View images & discuss actions of the personnel on vessel 15 Sec (...410); 9.4.1.3		417 View images & discuss actions of the personnel on vessel 15 Sec (...410); 9.4.1.3
		420 Plan response to situation – hit Lethal UAV with Mini UAV? 20 Sec (...410); 5.5.6
422 Reqst that UAV Plt point Mini UAV 4 at mid-ship container 6 Sec (...410); 9.3.1		
425 Study image of 2nd container & conclude that it may be UAV 14 Sec (...410); 7.3.5.2		

Part 3 IP/PCT Scenario of UAV Operations involving IAI Page 31
Min 41–60 Control of Multiple UAVs During Attack on Terrorist Vessel

TACNAV Up. Level Goals	UAV Pilot	Ex In

385 Observe Mini UAV 5 providing flight data and take control
8 Sec (...385); 7.3.2.1

404 Observe JATO UAV mounted in a container, men removing covers
8 Sec (...375); 7.3.5.2

400 Conduct low pass over boat and manoeuvre about vessel to view
Cont. (...375); 7.3.2.10

386 Put Mini UAV 5 in 800 ft circ. pattern around downed VTUAV 1
5 Sec (...385); 7.3.2.7

407 Observe second container which may be second Lethal UAV
4 Sec (...375); 7.3.5.2

387 Monitor flight pattern of Mini UAV 5 around VTUAV 1
Cont. (...385); 7.3.3.3

412 Monitor discussion regarding finding the terrorist vessel
12 Sec (...410); 9.2.1.10

391 "You have control" of Mini UAV 5
12 Sec (...385); 9.1.1

418 View images & discuss actions of the personnel on vessel
15 Sec (...410); 9.4.1.3

423 Receive request regarding manoeuvring Mini UAV 4
6 Sec (...410); 9.1.1

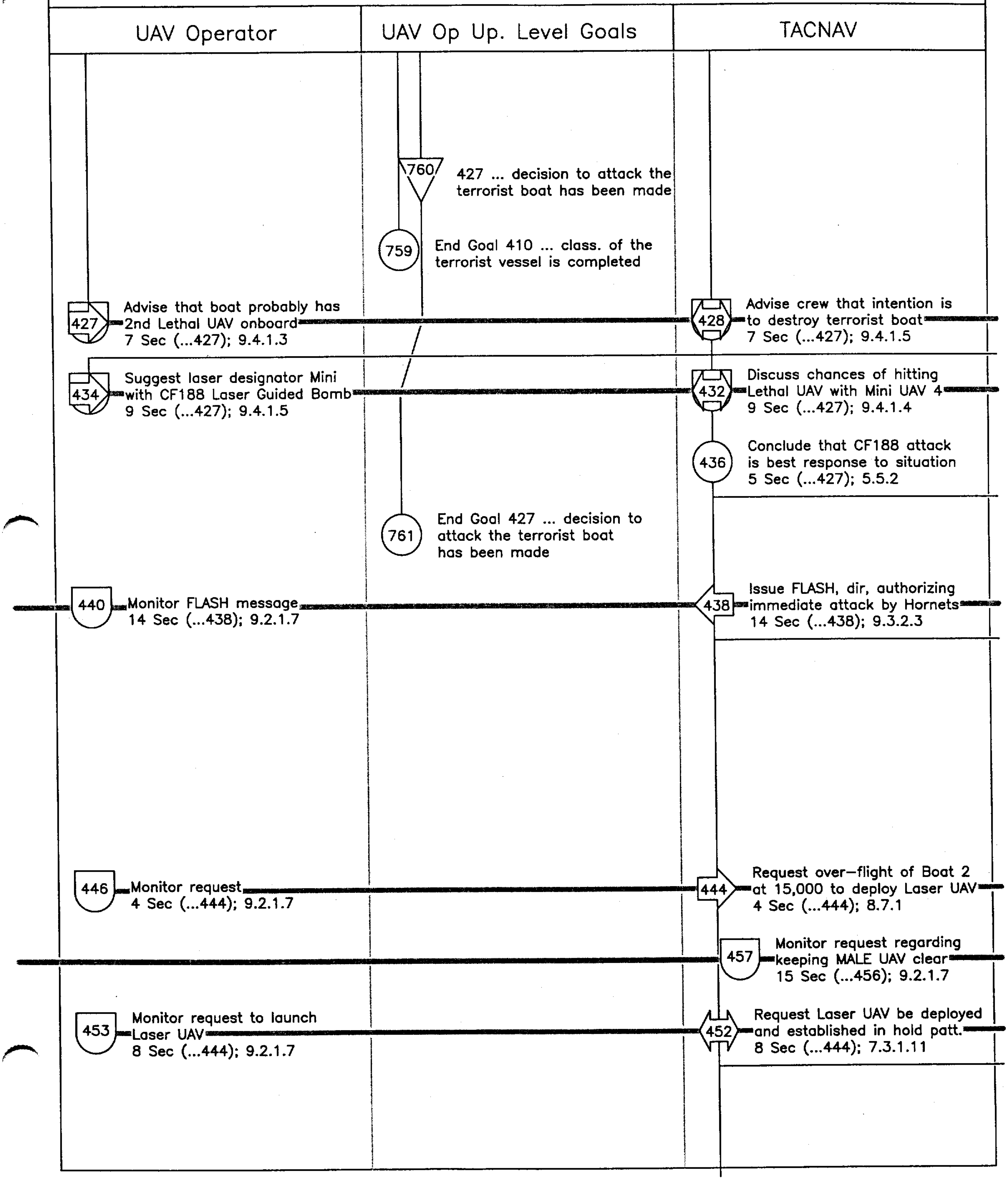
[Interrupt: Task No. 400]
Conduct low pass over boat and

Part 3 Min 41–60	IP/PCT Scenario of UAV Operations involving IAI Control of Multiple UAVs During Attack on Terrorist Vessel	Page 32

Ex Out	UAV Plt Up. Level Goals	Other Members of CP–140 Crew	Time Min/Sec
	756 385 ... Mini UAV 5 is employed over the downed VTUAV 1		9 42
			9 44
			9 44
			9 52
			9 52
			9 56
			9 56
			9 56
			9 57
			10 8
			10 8
	757 End Goal 385 ... Mini UAV 5 is employed over the downed VTUAV 1		10 17
			10 23
			10 23
			10 29

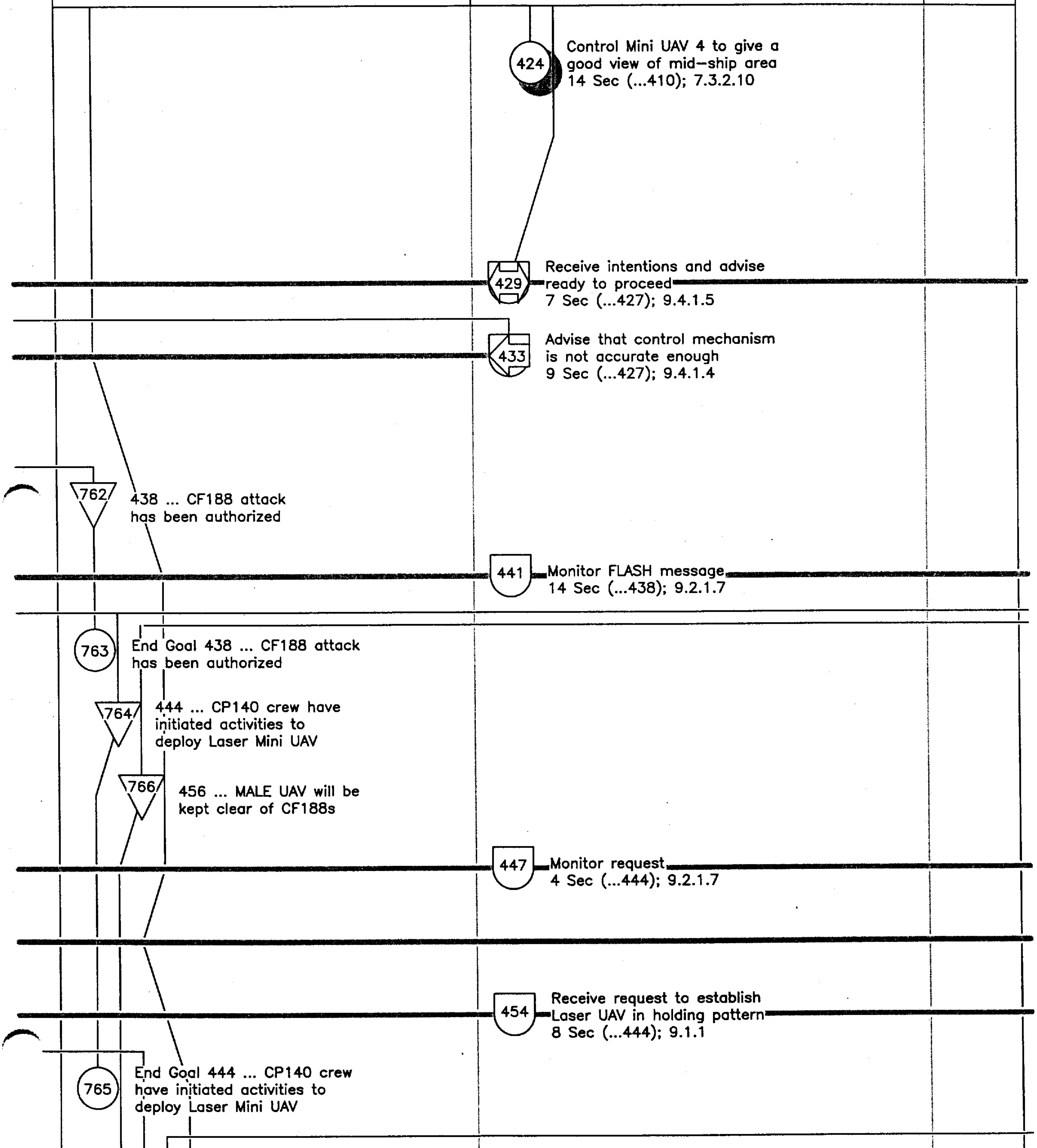
Part 3 Min 41–60	IP/PCT Scenario of UAV Operations involving IAI Control of Multiple UAVs During Attack on Terrorist Vessel		Page 33
Time Min/Sec	**Other Units: ROC, CPF**	**Mini UAVs**	**VTUAV**
10 29		619 Mini UAV 4 manoeuvres about mid-ship area	
10 43			
10 43			
10 43			
10 50			
10 59			
11 4			
11 4	439 (Hornets) Direction, authoriz. and authentication to attack 14 Sec (...438)		
11 18			
11 18			
11 18			
11 18			
11 18	458 (ROC) Receive request to keep MALE UAV clear of Fighters 15 Sec (...456)		
11 22			
11 30			

Part 3 IP/PCT Scenario of UAV Operations involving IAI Page 34
Min 41–60 Control of Multiple UAVs During Attack on Terrorist Vessel



Part 3 IP/PCT Scenario of UAV Operations involving IAI Page 35
Min 41–60 Control of Multiple UAVs During Attack on Terrorist Vessel

TACNAV Up. Level Goals	UAV Pilot	Ex In



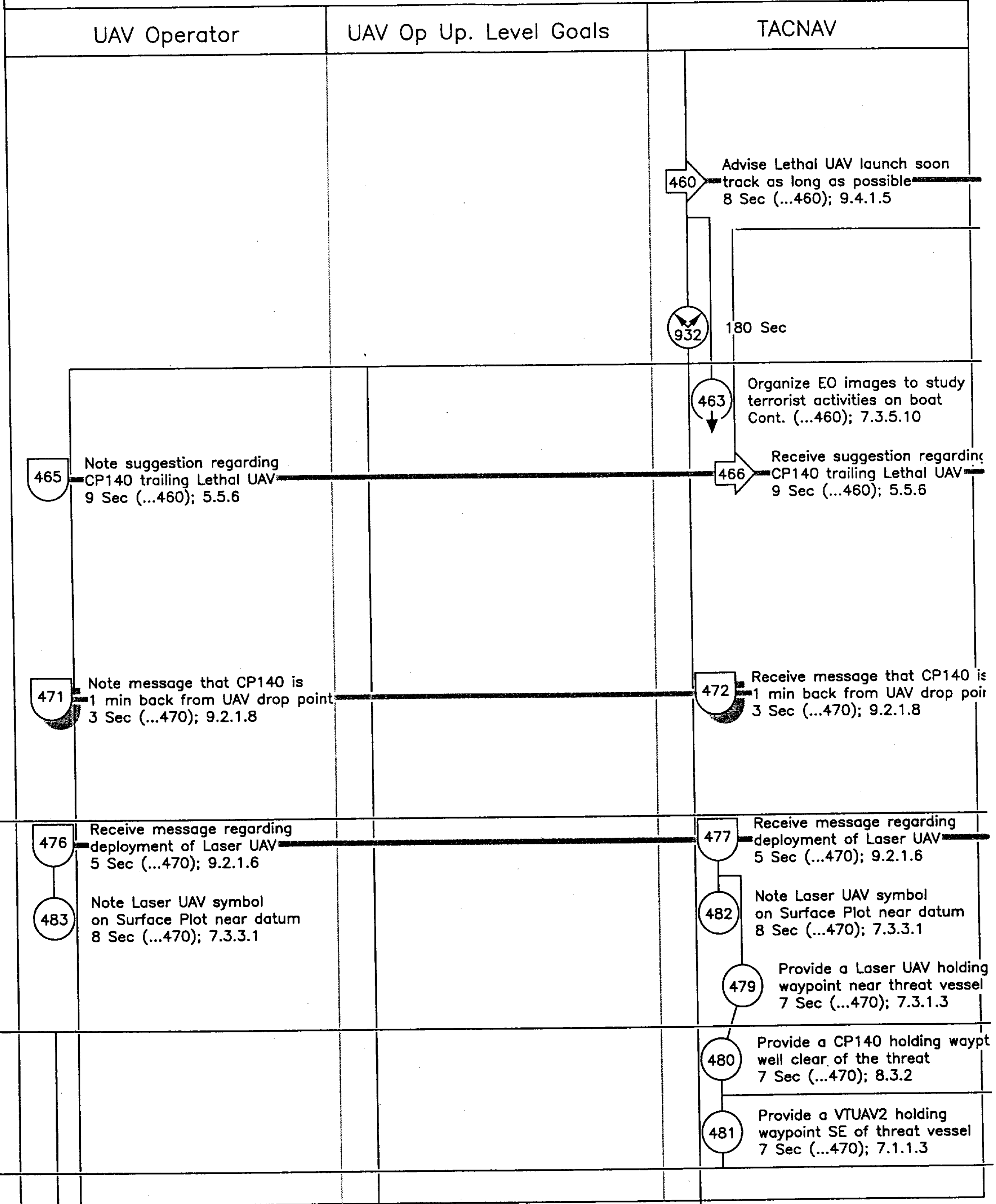
Part 3 IP/PCT Scenario of UAV Operations involving IAI
Min 41–60 Control of Multiple UAVs During Attack on Terrorist Vessel

Ex Out	UAV Plt Up. Level Goals	Other Members of CP–140 Crew	Time Min/Sec
			10 29
			10 43
			10 43
		430 (AC) Concur with decision to destroy terrorist boat 7 Sec (...427)	10 43
			10 50
			10 59
			11 4
		442 (AC) Monitor FLASH message 14 Sec (...438)	11 4
			11 18
			11 18
			11 18
		445 (AC) Receive request and advise 2 min back (15,000 ft) 4 Sec (...444)	11 18
		456 (NAVCOM) Request that (ROC) keep MALE UAV in SW sector 15 Sec (...456)	11 18
		455 (Ordnance) Receive request to prep Laser UAV for launch 8 Sec (...444)	11 22
		927 55 Sec	11 30

Part 3 IP/PCT Scenario of UAV Operations involving IAI Page 37
Min 41–60 Control of Multiple UAVs During Attack on Terrorist Vessel

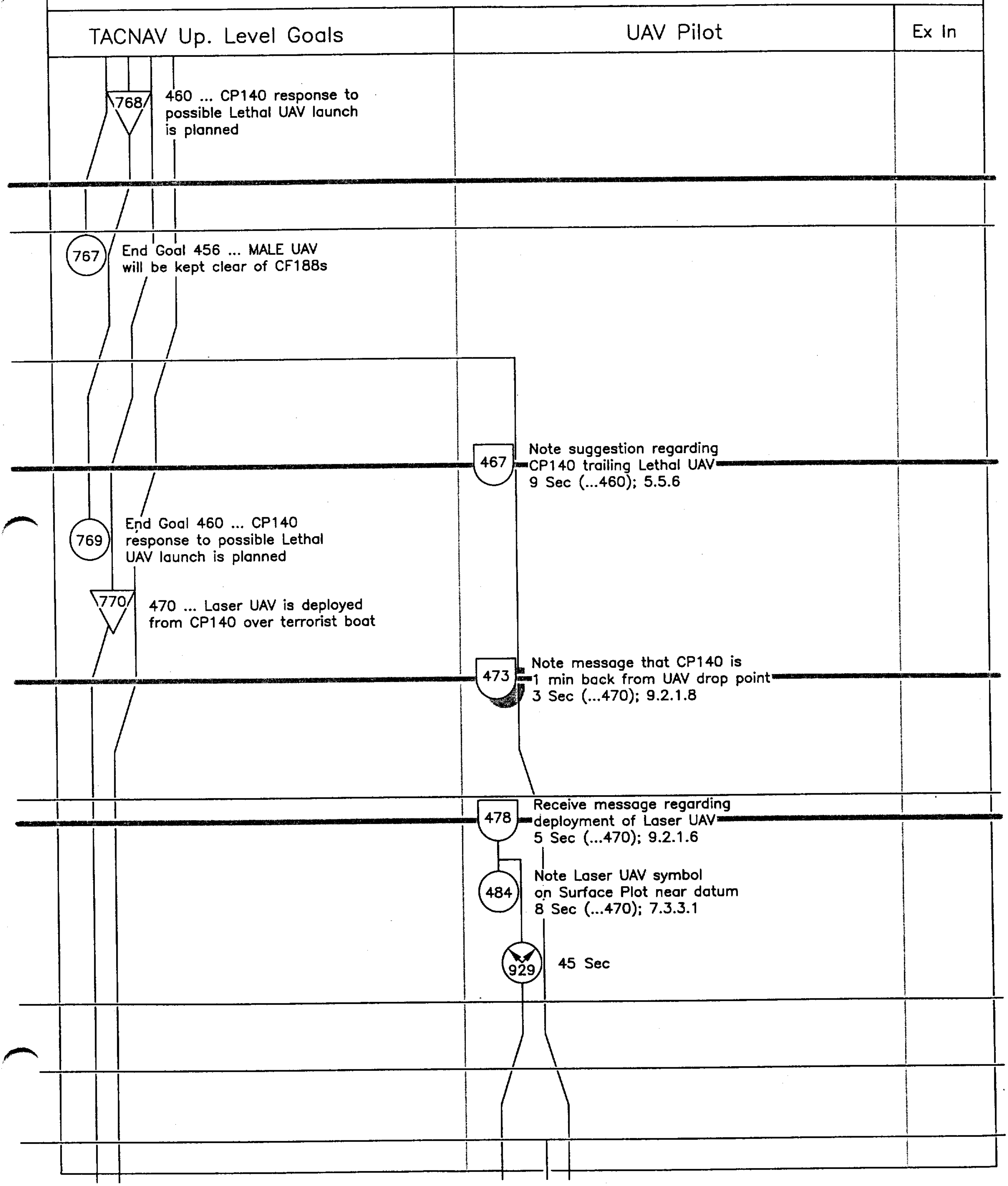
Time Min/Sec	Other Units: ROC, CPF	Mini UAVs	VTUAV
11 30			
11 30			
11 33			
11 38			
11 38			
11 38			
11 47			
12 25			
12 25			
13 28		620 Laser UAV released over terrorist boat	
13 33			
13 33			
13 40			
13 47			

Part 3 — IP/PCT Scenario of UAV Operations involving IAI — Page 38
Min 41–60 — Control of Multiple UAVs During Attack on Terrorist Vessel



Part 3 — IP/PCT Scenario of UAV Operations involving IAI — Page 39

Min 41–60 — Control of Multiple UAVs During Attack on Terrorist Vessel

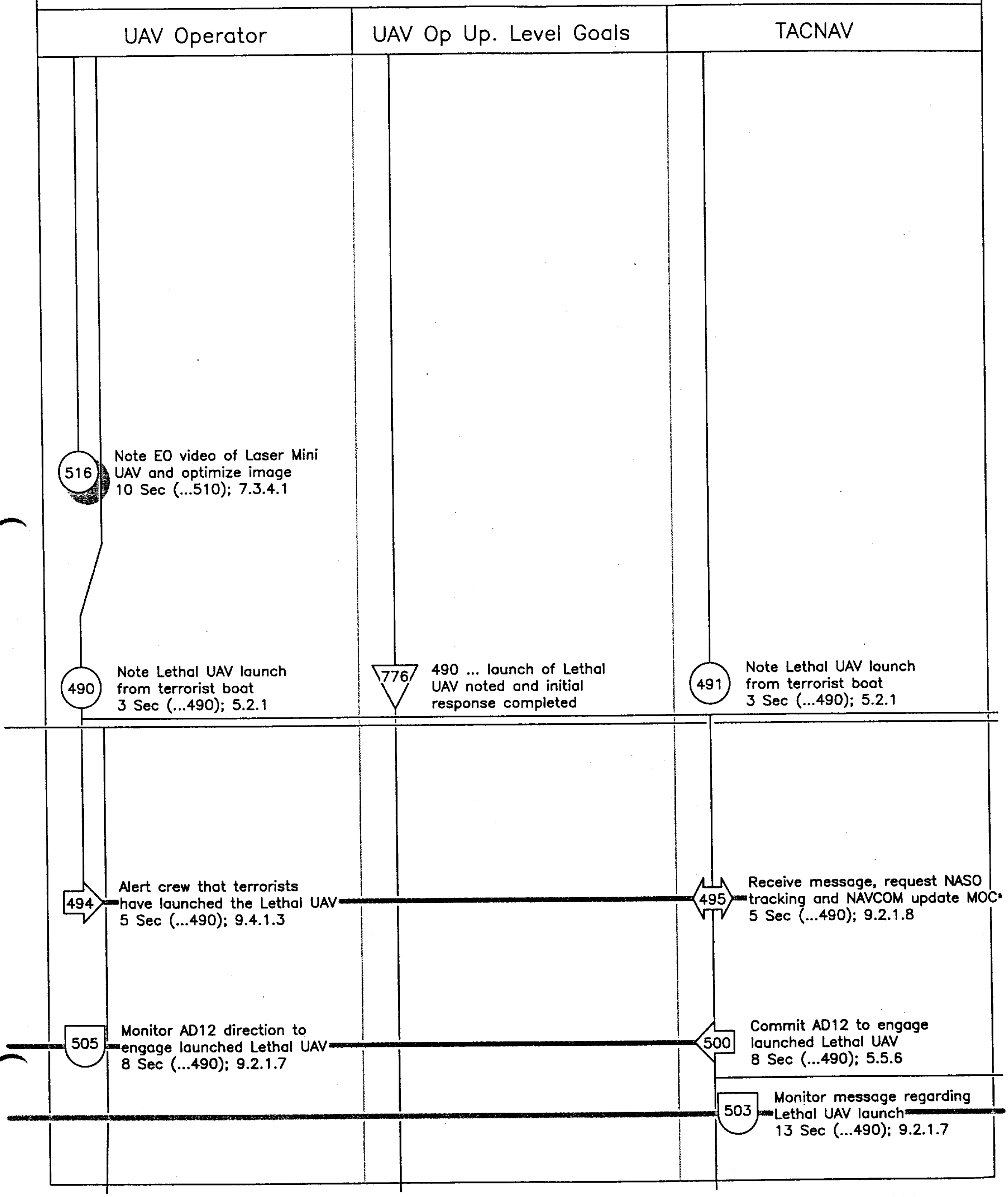


Part 3 IP/PCT Scenario of UAV Operations involving IAI Page 40
Min 41–60 Control of Multiple UAVs During Attack on Terrorist Vessel

Ex Out	UAV Plt Up. Level Goals	Other Members of CP–140 Crew	Time Min/Sec
			11 30
		461 (NASO1) Receive request to track Lethal UAV 8 Sec (...460)	11 30
			11 33
		462 (NASO1) Switches to Air–to–Air mode 7 Sec (...460)	11 38
			11 38
		464 (AC) Advise CP–140 could trail Lethal UAV 9 Sec (...460)	11 38
			11 47
			12 25
		470 (AC) Advise CP–140 1 min to drop point 3 Sec (...470)	12 25
		928 60 Sec	
		475 (AC) Advise Laser UAV released over terrorist boat 5 Sec (...470)	13 28
			13 33
			13 33
			13 40
		486 (AC) Turn CP140 to waypoint 11 Sec (...470)	13 47

Part 3 Min 41–60	IP/PCT Scenario of UAV Operations involving IAI Control of Multiple UAVs During Attack on Terrorist Vessel		Page 41
Time	**Other Units: ROC, CPF**	**Mini UAVs**	**VTUAV**
Min/Sec			
13 54			[Interrupt: Task No. 606] Heading maintained towards
13 55			621 VTUAV 2 turns towards holdi waypoint SE of terrorist boa
14 3			622 Maintain track to waypoint
14 5			
14 8			
14 18		623 Laser UAV provides flight data	
14 26		624 Laser UAV establishes 800 ft flight to holding waypoint	
14 31		625 Laser UAV maintains track to holding point	
14 38			
14 38			
14 41			
14 46			
14 46	501 (AD12) Receive direction to engage launched Lethal UAV 8 Sec (...490)		
14 53	504 (MOC) Receive message regarding Lethal UAV launch 13 Sec (...490)		

Part 3 IP/PCT Scenario of UAV Operations involving IAI Page 42
Min 41–60 Control of Multiple UAVs During Attack on Terrorist Vessel



Part 3 IP/PCT Scenario of UAV Operations involving IAI Page 43
Min 41–60 Control of Multiple UAVs During Attack on Terrorist Vessel

TACNAV Up. Level Goals	UAV Pilot	Ex In

[Interrupt: Task No. 272]
Monitor VTUAV 2 on heading

524 Turn VTUAV2 towards holding waypoint SE of threat vessel
9 Sec (...524); 7.1.2.1

525 Verify that VTUAV2 will be clear of CF188 intended track
5 Sec (...524); 7.1.1.1

771 End Goal 470 ... Laser UAV is deployed from CP140 over terrorist boat

527 Monitor VTUAV 2 on heading to the holding point
Cont. (...524); 7.1.3

510 Observe Laser Mini UAV flight data and take control
8 Sec (...510); 7.3.2.1

512 Establish Laser Mini UAV in 800 ft flight to holding waypt
5 Sec (...510); 7.3.2.7

514 Monitor flight path of Laser Mini UAV
Cont. (...510); 7.3.3.3

930 35 Sec

492 Note Lethal UAV launch from terrorist boat
3 Sec (...490); 5.2.1

496 Receive message regarding launch of Laser UAV
5 Sec (...490); 9.2.1.6

Part 3 Min 41–60	IP/PCT Scenario of UAV Operations involving IAI Control of Multiple UAVs During Attack on Terrorist Vessel	Page 44

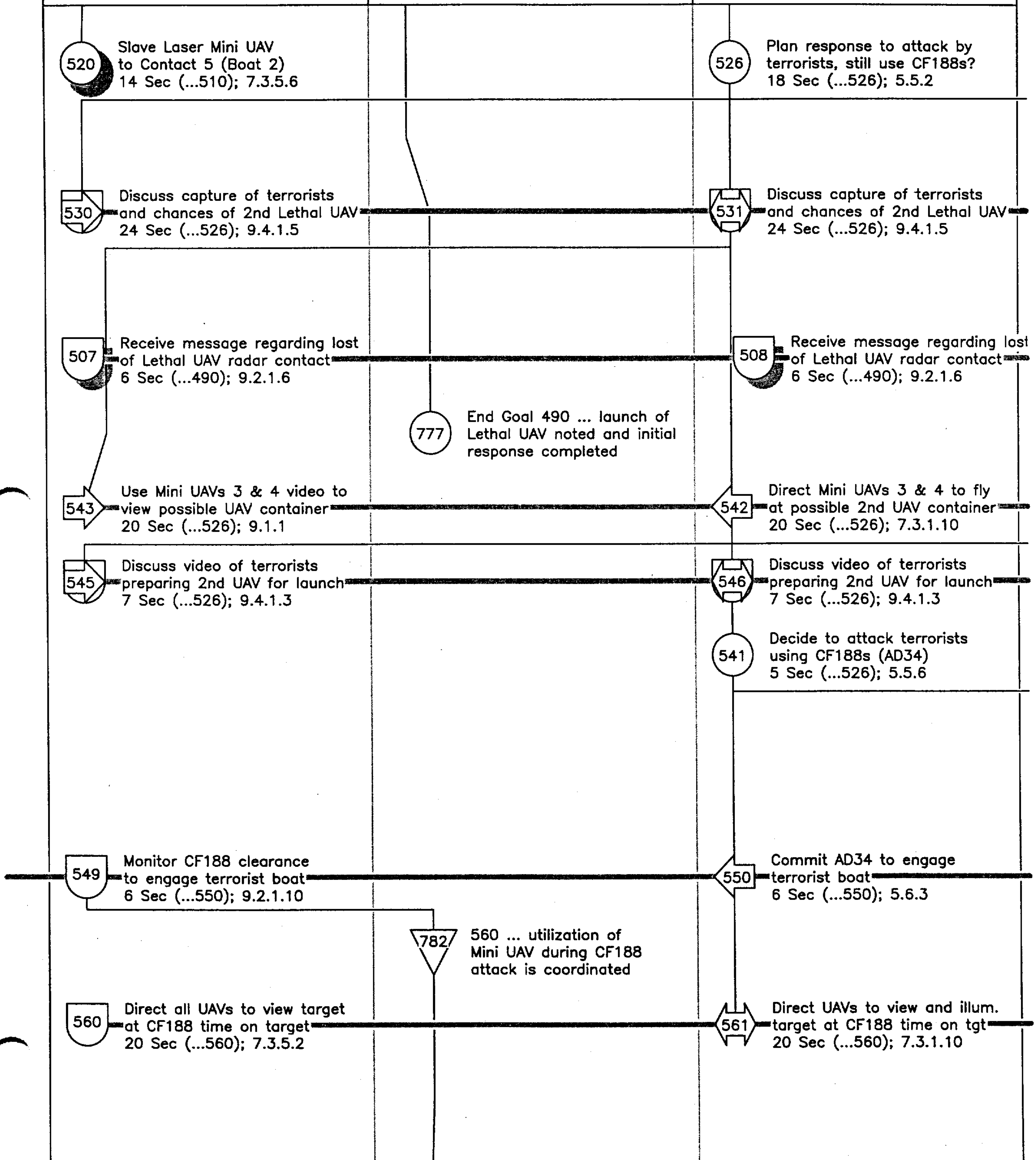
Ex Out	UAV Plt Up. Level Goals	Other Members of CP–140 Crew	Time Min/Sec
	774 524 ... VTUAV 2 will remain clear of CF188 attack		13 54
		487 (AC) Maintain level flight to waypoint at 15,000 ft 120 Sec (...470)	13 55
			14 3
			14 5
	775 End Goal 524 ... VTUAV 2 will remain clear of CF188 attack		14 8
	772 510 ... control of the Laser UAV is established		14.18
			14 26
			14 31
			14 38
			14 38
		934 45 Sec	
		497 (NASO1) Receive message regarding tracking Lethal UAV 5 Sec (...490)	14 41
		498 (NASO1) Initiate tracking of Lethal UAV 8 Sec (...490)	14 46
		499 (NAVCOM) Prepare FLASH message 7 Sec (...490)	14 46
		502 (NAVCOM) Transmit FLASH message of Lethal UAV launch 13 Sec (...490)	14 53

Part 3	IP/PCT Scenario of UAV Operations involving IAI		Page 45
Min 41–60	Control of Multiple UAVs During Attack on Terrorist Vessel		
Time	**Other Units: ROC, CPF**	**Mini UAVs**	**VTUAV**
Min/Sec			
14 58		[Interrupt: Task No. 625] Laser UAV maintains track	
15 6		626 Laser UAV establishes holding pattern	
15 11		628 Laser on UAV slaves to Boat 2	
15 16		627 Laser UAV maintains holding pattern	
15 26			
15 32			
15 36			
15 56			
16 3			
16 8			
16 8			
16 8	548 (AD34) Receive direction to engage terrorist boat 6 Sec (...550)		
16 14	926 48 Sec		
16 14			

Part 3 — IP/PCT Scenario of UAV Operations involving IAI — Page 46

Min 41–60 — Control of Multiple UAVs During Attack on Terrorist Vessel

UAV Operator	UAV Op Up. Level Goals	TACNAV



Part 3 IP/PCT Scenario of UAV Operations involving IAI Page 47
Min 41–60 Control of Multiple UAVs During Attack on Terrorist Vessel

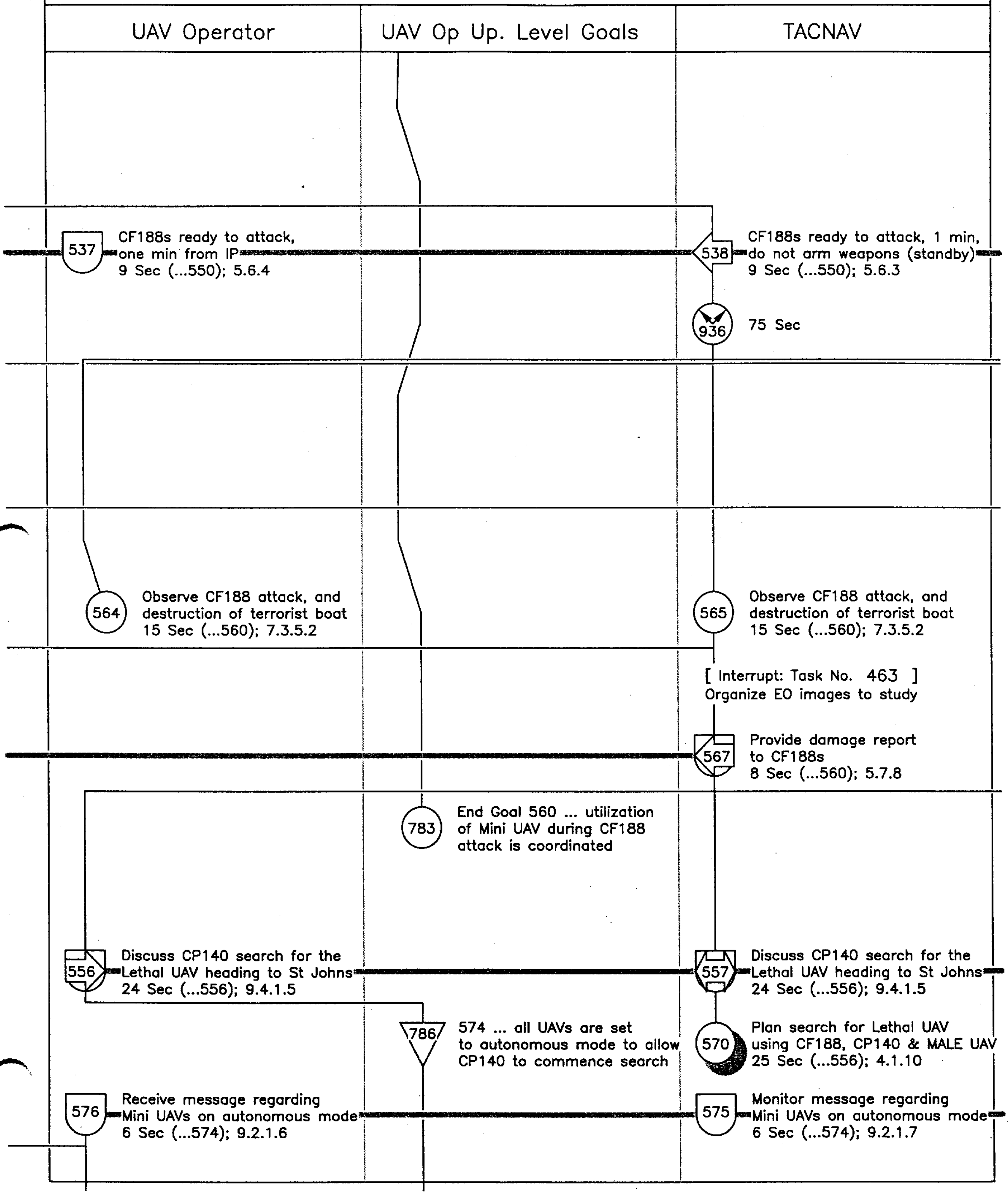
TACNAV Up. Level Goals	UAV Pilot	Ex In
778 — 526 ... reassessment of the need to attack the terrorists is completed	[Interrupt: Task No. 514] Monitor flight path of	
	518 — Establish Laser Mini UAV in holding pattern 8 Sec (...510); 7.3.2.7	
	532 — Discuss capture of terrorists and chances of 2nd Lethal UAV 24 Sec (...526); 9.4.1.5	
	519 — Monitor Laser Mini UAV flight in holding pattern Cont. (...510); 7.3.3.3	
	509 — Receive message regarding lost of Lethal UAV radar contact 6 Sec (...490); 9.2.1.6	
	544 — Monitor direction to use Mini UAVs 3 & 4 20 Sec (...526); 9.2.1.7	
	547 — Discuss video of terrorists preparing 2nd UAV for launch 7 Sec (...526); 9.4.1.3	
780 — 550 ... CF188s are committed to attack and UAVs are clear of the Hornet's flight path		
779 — End Goal 526 ... reassessment of the need to attack the terrorists is completed		
	551 — Monitor CF188 clearance to engage terrorist boat 6 Sec (...550); 9.2.1.10	
	562 — Direct Laser UAV to illuminate boat at CF188 time on target 20 Sec (...560); 9.1.1	
	[Interrupt: Task No. 519] Monitor Laser Mini UAV	

Part 3 IP/PCT Scenario of UAV Operations involving IAI Page 48
Min 41–60 Control of Multiple UAVs During Attack on Terrorist Vessel

Ex Out	UAV Plt Up. Level Goals	Other Members of CP–140 Crew	Time
			Min/Sec
			14 58
			15 6
		533 (AC) Discuss capture of terrorists & 2nd Lethal UAV 24 Sec (...526)	15 11
	773 End Goal 510 ... control of the Laser UAV is established		15 16
		506 (NAS01) Tell crew that Lethal UAV radar contact lost in turn 6 Sec (...490)	15 26
			15 32
			15 36
			15 56
			16 3
			16 8
			16 8
		552 (AC) Monitor CF188 clearance to engage terrorist boat 6 Sec (...550)	16 8
			16 14
			16 14

Time Min/Sec	Other Units: ROC, CPF	Mini UAVs	VTUAV
16 34			
17 2	535 (CF188s) Note 1 minute back from IP 2 Sec (...550)		
17 4	536 (CF188s) Ready to attack, one min from IP 9 Sec (...550)		
17 13			
		[Interrupt: Task No. 627] Laser UAV maintains	
17 21		629 Mini UAVs 2, 3, 4 & 5 descend to 100 ft to avoid CF188s	
17 26			[Interrupt: Task No. 622] Maintain track
18 13			630 VTUAV 2 approaches and maintains a hover
18 43	568 (CF188s) Receive damage report from CP140 TACNAV 8 Sec (...560)		
18 49			
18 51			
18 51			
19 15			
19 15			

Part 3 IP/PCT Scenario of UAV Operations involving IAI Page 50
Min 41–60 Control of Multiple UAVs During Attack on Terrorist Vessel



Part 3 Min 41–60 IP/PCT Scenario of UAV Operations involving IAI Control of Multiple UAVs During Attack on Terrorist Vessel Page 51

TACNAV Up. Level Goals	UAV Pilot	Ex In

555 Plan route for Laser UAV for CF188 LGB attack
18 Sec (...560); 7.3.1.8

539 CF188s ready to attack, one min from IP
9 Sec (...550); 5.6.4

553 Command Mini UAVs to descend to 100 ft ASL to avoid CF188s
8 Sec (...550); 7.3.2.4

[Interrupt: Task No. 527]
Monitor VTUAV 2 on heading

554 Command VTUAV2 to approach and maintain a hover, anti-col ON
5 Sec (...550); 7.1.2.5

781 End Goal 550 ... CF188s are committed to attack and UAVs are clear of the flight path

566 Observe CF188 attack, and destruction of terrorist boat
15 Sec (...560); 7.3.5.2

784 556 ... search for the Lethal UAV is discussed and search plan initiated

558 Discuss CP140 search for the Lethal UAV heading to St Johns
24 Sec (...556); 9.4.1.5

574 Advise UAV Op that Mini UAVs on autonomous mode about datum
6 Sec (...574); 9.4.1.5

Part 3 Min 41–60 — IP/PCT Scenario of UAV Operations involving IAI Control of Multiple UAVs During Attack on Terrorist Vessel — Page 52

Ex Out	UAV Plt Up. Level Goals	Other Members of CP–140 Crew	Time Min/Sec
			16 34
			17 2
		540 (AC) CF188s ready to attack, one min from IP 9 Sec (...550)	17 4
			17 13
			17 21
			17 26
			18 13
			18 43
			18 49
			18 51
		559 (AC) Discuss search for the Lethal UAV heading to St Johns 24 Sec (...556)	18 51
			19 15
			19 15

Part 3 Min 41–60	IP/PCT Scenario of UAV Operations involving IAI Control of Multiple UAVs During Attack on Terrorist Vessel		Page 53
Time	**Other Units: ROC, CPF**	**Mini UAVs**	**VTUAV**
Min/Sec			
19 21		[Interrupt: Task No. 629] Mini UAVs 2, 3, 4 & 5 descend	
19 31		631 All Mini UAVs commence auton– omous mode to view Boat 2	
19 51			
19 55			
20 0			
20 12			
		[Interrupt: Task No. 631] All Mini UAVs commence auton–	[Interrupt: Task No. 630] VTUAV 2 approaches and

Part 3 Min 41–60	IP/PCT Scenario of UAV Operations involving IAI Control of Multiple UAVs During Attack on Terrorist Vessel	Page 54

UAV Operator	UAV Op Up. Level Goals	TACNAV
572 Set Mini UAVs to autonomous mode to view sinking boat 45 Sec (...574); 7.3.2.6		
582 Receive message regarding VTUAV 2 on autonomous mode 5 Sec (...574); 9.2.1.6		581 Monitor message regarding VTUAV 2 on autonomous mode 5 Sec (...574); 9.2.1.7
584 Monitor site of explosion with all available video sensors Cont. (...574); 7.3.5.2		590 Prepare for handover of VTUAV 2 on autonomous mode 5 Sec (...574); 7.1.1.11
	787 End Goal 574 ... all UAVs are set to autonomous mode to allow CP140 to search	990 Network Task: End of Part 3, End of Scenario
[Interrupt: Task No. 584] Monitor site of explosion with		

TACNAV Up. Level Goals	UAV Pilot	Ex In
	578 Plan route for VTUAV 2 to view boat, clear of Mini UAVs 30 Sec (...574); 7.1.1.1	
785 End Goal 556 ... search for the Lethal UAV is discussed and search plan initiated		
732 244 ... new ISAR imagery of Boat 2 is downloaded and studied	579 Initiate VTUAV 2 autonomous mode to follow planned route 4 Sec (...574); 7.1.2.4	
	580 Advise UAV Op that VTUAV 2 on autonomous mode about datum 5 Sec (...574); 9.4.1.4	

Part 3 Min 41–60	IP/PCT Scenario of UAV Operations involving IAI Control of Multiple UAVs During Attack on Terrorist Vessel		Page 56
Ex Out	UAV Plt Up. Level Goals	Other Members of CP–140 Crew	Time Min/Sec
			19 21
			19 31
			19 51
			19 55
			20 0
			20 12

ANNEX C

HIERARCHICAL GOAL ANALYSIS

14 June 2004

ANNEX C
HIERARCHICAL GOAL ANALYSIS

C.1.0 GENERAL

This Annex contains the results of both the top down development of a CP140 UAV crew HGA (Section C.2.0) and a bottom up development of a mission oriented HGA (Section C.2.1, C.2.2 and C.2.3). The bottom up analysis has been completed for each part of the mission, that is, for each of the three 20 minute sections described in the mission scenario.

C.2.0 Top Down Goal Analysis

Table C-1 lists 10 goals, which comprise the First Level Goals of the Top Down Goal Analysis, and provides cross-references to tables in this section that describe the analysis of these goals in detail.

Table C-1 Top Down Goals – I want to perceive (that) (the)…

Goal	Description	Refer To
1	…Canadian sovereignty is enforced	Table C-2
2	…situational awareness is maintained	Table C-3
3	…OTC support functions are conducted	Table C-4
4	…unknown vessels are sought and identified	Table C-5
5	…reaction to a terrorist threat	Table C-6
6	…tactical mission planning is conducted	Table C-7
7	…UAVs are employed	Table C-8
8	…CP140 terrorist patrol navigation is conducted	Table C-9
9	…communications are maintained	Table C-10
10	…systems are monitored and managed	Table C-11

Table C-2 Top Down Goal Analysis – Goal 1 … Canadian sovereignty is enforced

Number	Level 1 2 3 4 5 Goal/Objective and Subgoals/Subobjectives	IAI Candidate	Influenced Variable	Assignment	Completion Time (Sec)	Notes
Top	I want to perceive the (...) conduct of the terrorist patrol mission					
1	**... Canadian sovereignty is enforced**					
1.1	... aid to the Civil Power					Not used in scenario
1.2	... peacetime surveillance and control					Not used in scenario
1.3	... Canadian borders are secure against illegal activities					
1.3.1	... a listening watch for OGD transmissions					Not used in scenario
1.4	... protection of Canadian fisheries					
1.4.1	... a listening watch for DFO transmissions					Not used in scenario Similar to 1.3.1
1.4.2	... maintenance of a current fisheries permit list					Not used in scenario
1.4.3	... maintenance of a current plot of open fisheries areas					Not used in scenario
1.4.4	... surveillance territorial waters					Not used in scenario
1.4.5	... cross-referencing of identified boats against permit list					Not used in scenario

Table C-2 Top Down Goal Analysis – Goal 1 … Canadian sovereignty is enforced

Number	Level 1 2 3 4 5 Goal/Objective and Subgoals/Subobjectives	IAI Candidate	Influenced Variable	Assignment	Completion Time (Sec)	Notes
1.5	... response to natural and man-made disasters					Not used in scenario
1.6	... conduct of search and rescue activities					
1.6.1	... a listening watch for emergency transmissions					Not used in scenario Similar to 1.3.1

Table C-3 Top Down Goal Analysis – Goal 2 … situational awareness is maintained

Number	Level 1 2 3 4 5 Goal/Objective and Subgoals/Subobjectives	IAI Candidate	Influenced Variable	Assignment	Completion Time (Sec)	Notes
Top	I want to perceive the (...) conduct of the terrorist patrol mission					
2	**… situational awareness is maintained**					
2.1	... tactical plot is current					
2.1.1	... radar plot of an area of interest is current	Yes	Currency	TACNAV	4 to 9	
2.1.2	... radar plot of an airborne contact of interest is current					Not used in scenario
2.1.3	... radar plot of a vessel is current					Not used in scenario
2.1.4	... tactical plot icons are current		Currency	UAV Op	8	
2.2	... potential threat information is collected					
2.2.1	... threat information is collected from ac systems					Not used in scenario
2.2.2	... threat information is collected from tasking agency					Not used in scenario
2.2.3	... threat information is collected from other units					Not used in scenario
2.2.4	... threat information is collected from other crewmembers					Not used in scenario
2.3	... location, identification and mission activities of friendly units					
2.3.1	... workstation is formatted to display the tactical plot					Not used in scenario

Table C-3 Top Down Goal Analysis – Goal 2 … situational awareness is maintained

Number	Level 1 2 3 4 5 Goal/Objective and Subgoals/Subobjectives	IAI Candidate	Influenced Variable	Assignment	Completion Time (Sec)	Notes
2.3.2	... location of friendly units					
2.3.2.1	... location of all friendly unit icons on tactical plot					Not used in scenario
2.3.2.2	... relative location of CP140 to friendly units					Not used in scenario
2.3.3	... identification of friendly units					Not used in scenario
2.3.4	... mission activities of friendly units					
2.3.4.1	... course and speed of friendly units					Not used in scenario
2.3.4.2	... activities of friendly units					Not used in scenario
2.3.4.3	... relationship of friendly unit activities to mission					Not used in scenario
2.4	... location and identification of neutral units					
2.4.1	... workstation is formatted to display the tactical plot					Not used in scenario Duplicate of 2.3.1
2.4.2	... location of neutral units					
2.4.2.1	... location of all neutral unit icons on tactical plot					Not used in scenario Duplicate of 2.3.2.1
2.4.2.2	... relative location of CP140 to neutral units					Not used in scenario Duplicate of 2.3.2.2
2.4.3	... identification of neutral units					Not used in scenario Duplicate of 2.3.3
2.5	... location of unknown units					
2.5.1	... workstation is formatted to display the tactical plot					Not used in scenario Duplicate of 2.3.1

Table C-3 Top Down Goal Analysis – Goal 2 … situational awareness is maintained

Number	Level 1 2 3 4 5 / Goal/Objective and Subgoals/Subobjectives	IAI Candidate	Influenced Variable	Assignment	Completion Time (Sec)	Notes
2.5.2	... location of unknown units					
2.5.2.1	... location of all unknown unit icons on tactical plot	Yes	Location	TACNAV	6 to 16	Duplicate of 2.3.2.1
2.5.2.2	... relative location of CP140 to unknown units					Duplicate of 2.3.2.2
2.6	... location and identification of terrorist units					
2.6.1	... workstation is formatted to display the tactical plot					Duplicate of 2.3.1
2.6.2	... location of known terrorist units					
2.6.2.1	... location of all known terrorist unit icons on tactical plot					Duplicate of 2.3.2.1
2.6.2.2	... relative location of CP140 to known terrorist units					Duplicate of 2.3.2.2
2.6.3	... identification of known terrorist units					Duplicate of 2.3.3
2.7	... all tactical crew member activities					
2.7.1	... NASO activities					Not used in scenario
2.7.1.1	... aircraft descent has been cleared using radar		Clearance	TACNAV	10	
2.7.1.2	... contact GENTRACK has been generated		GENTRACK	TACNAV	10	
2.7.1.3	... on-board EO subsystem has been configured		Configuration	TACNAV	10	
2.7.2	... NAVCOM activities					
2.7.2.1	... tasking acknowledgement has been transmitted					Not used in scenario
2.7.2.2	... tactical radio nets have been established					Not used in scenario
2.7.2.3	... tactical chat rooms have been established					Not used in scenario

Table C-3 Top Down Goal Analysis – Goal 2 … situational awareness is maintained

Number	Level 1 2 3 4 5	Goal/Objective and Subgoals/Subobjectives	IAI Candidate	Influenced Variable	Assignment	Completion Time (Sec)	Notes
2.7.3		... UAV Op activities					Not used in scenario
2.7.4		... UAV Plt activities					Not used in scenario
2.7.5		... TACNAV activities					Not used in scenario

Table C-4 Top Down Goal Analysis – Goal 3 … OTC support functions are conducted

Number	Level 1 2 3 4 5 Goal/Objective and Subgoals/Subobjectives	IAI Candidate	Influenced Variable	Assignment	Completion Time (Sec)	Notes
Top	I want to perceive the (...) conduct of the terrorist patrol mission					
3	**... OTC support functions are conducted**					
3.1	... capabilities of friendly forces					
3.1.1	... list of friendly units in the area and their location		List	TACNAV	5	
3.1.2	... onboard information of capabilities of each friendly unit					Not used in scenario
3.1.3	... list of missing information regarding friendly units					Not used in scenario
3.1.4	... message requesting current capabilities of units					Not used in scenario
3.1.5	... reception of friendly units capabilities information					Not used in scenario
3.1.6	... assimilation of friendly units capabilities information					Not used in scenario
3.2	... current tasking of friendly forces					
3.2.1	... onboard information of tasking of each friendly unit					Not used in scenario
3.2.2	... currency of tasking information					Not used in scenario
3.2.3	... identification of friendly units without current tasking info					Not used in scenario

Table C-4 Top Down Goal Analysis – Goal 3 … OTC support functions are conducted

Number	Level 1 2 3 4 5	Goal/Objective and Subgoals/Subobjectives	IAI Candidate	Influenced Variable	Assignment	Completion Time (Sec)	Notes
3.2.4		... message requesting current tasking of units					Not used in scenario Similar to 3.1.4
3.2.5		... reception of friendly units tasking information					Not used in scenario Similar to 3.1.5
3.2.6		... assimilation of friendly units tasking information					Not used in scenario Similar to 3.1.6
3.3		... new tasking for friendly forces					
3.3.1		... task to be completed					Not used in scenario
3.3.2		... selection of unit capable of completing the tasking					Not used in scenario
3.3.3		... tasking has been planned					Not used in scenario
3.3.4		... tasking message has been transmitted					Not used in scenario
3.3.5		... tasking message has been acknowledged					Not used in scenario
3.4		... communications maintained between friendly forces					
3.4.1		... prompt reporting is ensured					Not used in scenario
3.4.2		... chat rooms are maintained					Not used in scenario
3.4.3		... chat room logs are updated					Not used in scenario
3.4.4		... radio nets monitored					Not used in scenario
3.4.5		... radio log maintained					Not used in scenario

Table C-4 Top Down Goal Analysis – Goal 3 … OTC support functions are conducted

Number	Level 1 2 3 4 5 Goal/Objective and Subgoals/Subobjectives	IAI Candidate	Influenced Variable	Assignment	Completion Time (Sec)	Notes
3.5	... command and control of the tactical situation is assured					
3.5.1	... command & control of tactical situation is assessed		C&C	TACNAV	12	
3.5.2	... a determination of the SAC (OSC) is completed		Determination	TACNAV	12	

Table C-5 Top Down Goal Analysis – Goal 4 … unknown vessels are sought and identified

Number	Level 1 2 3 4 5 Goal/Objective and Subgoals/Subobjectives	IAI Candidate	Influenced Variable	Assignment	Completion Time (Sec)	Notes
Top	I want to perceive the (...) conduct of the terrorist patrol mission					
4	**... unknown vessels are sought and identified**					
4.1	... surface plot is reviewed					
4.1.1	... tactical plot configured to find unknown vessels					Not used in scenario
4.1.2	... geographical bounds placed on the area of interest					Not used in scenario
4.1.3	... the removal of all verified friendly contact icons					Not used in scenario
4.1.4	... the removal of all verified neutral contact icons					Not used in scenario
4.1.5	... latest position of all unknown contacts is plotted		Position	UAV Op	8 to 15	
4.1.6	... MLA and speed are applied to unknown contacts					Not used in scenario
4.1.7	... dead reckoning location of unknown contacts is plotted					Not used in scenario
4.1.8	... available data is matched to anticipated locations					Not used in scenario
4.1.9	... identified contacts are removed from tactical plot					Not used in scenario
4.1.10	... search plan for airborne threat is produced	Yes	Plan	TACNAV	25	
4.2	... search for contacts is complete					
4.2.1	... contact is visually sought by flight crew					TACNAV responsibility

Table C-5 Top Down Goal Analysis – Goal 4 … unknown vessels are sought and identified

Number	Level 1 2 3 4 5 Goal/Objective and Subgoals/Subobjectives	IAI Candidate	Influenced Variable	Assignment	Completion Time (Sec)	Notes
4.2.2	... contact is visually sought by tactical crew					TACNAV responsibility
4.2.3	... contact is sought by CP140 crew using radar					TACNAV responsibility
4.2.4	... contact is visually sought by CP140 crew using EO suite					TACNAV responsibility
4.2.5	... contact is sought using UAV radar		Contact found	UAV Op	10 to Cont.	
4.2.6	... contact is visually sought using UAV EO suite					
4.3	... classification of contacts					
4.3.1	... found contacts are compared against known parameters		Comparison	UAV Op	10	NASO1 for CP140 radar
4.3.2	... matches are made with parameters					NASO1 for CP140 radar
4.3.3	... classification of contacts is made					NASO1 for CP140 radar
4.4	... identification of contacts					
4.4.1	… CP140 is within visual range of unidentified contact					Not used in scenario
4.4.2	... flight or tactical crew visually identifying vessel					Not used in scenario TACNAV responsibility
4.4.3	... tactical crew identifying vessel using CP140 EO suite		Identification	UAV Op	5	Not used in scenario TACNAV responsibility
4.4.4	... UAV asset is within EO viewing range of contact					Not used in scenario
4.4.5	... crew identifying vessel using UAV EO suite	Yes	Identification	UAV Op	5 to Cont.	
4.4.6	… ISAR imagery is downloaded and analysed		Imagery	TACNAV	6	TACNAV responsibility
4.4.7	... UAV images of boat are compared with database	Yes	Comparison	UAV Op	8 to 14	

Table C-5 Top Down Goal Analysis – Goal 4 … unknown vessels are sought and identified

Number	Level 1 2 3 4 5	Goal/Objective and Subgoals/Subobjectives	IAI Candidate	Influenced Variable	Assignment	Completion Time (Sec)	Notes
4.4.8		... crew classify vessel using UAV EO suite	Yes	Classification	UAV Op	5 to 12	
4.4.9		... legality of fishing boat activities	Yes	Legality	UAV Op	6 to 14	TACNAV responsibility
4.4.10		... contact can be identified		Identification	TACNAV	4	

Table C-6 Top Down Goal Analysis – Goal 5 … reaction to a terrorist threat

Number	Level Goal/Objective and Subgoals/Subobjectives 1 2 3 4 5	IAI Candidate	Influenced Variable	Assignment	Completion Time (Sec)	Notes
Top	I want to perceive the (...) conduct of the terrorist patrol mission					
5	**… reaction to a terrorist threat**					
5.1	... rules of engagement are reviewed					
5.1.1	... review of electronic books technologies list of docs					Not used in scenario
5.1.2	... selection of rules of engagement					Not used in scenario
5.1.3	... relevant rules of engagement are reviewed		Rules	TACNAV	8	
5.1.4	... relevant rules of engagement are committed to memory					Not used in scenario
5.2	... activities of terrorist unit					
5.2.1	... overt actions of terrorist unit personnel are observed		Actions	TACNAV	3	
5.2.2	... equipment used by terrorist unit personnel is identified					Not used in scenario
5.2.3	... intentions of terrorist unit personnel are determined					Not used in scenario
5.3	... terrorist threat to friendly forces					
5.3.1	... potential weapons onboard terrorist unit		Weapons	TACNAV	6	

Table C-6 Top Down Goal Analysis – Goal 5 … reaction to a terrorist threat

Number	Level 1 2 3 4 5 Goal/Objective and Subgoals/Subobjectives	IAI Candidate	Influenced Variable	Assignment	Completion Time (Sec)	Notes
5.3.2	... threat envelope of terrorist weapons					Not used in scenario
5.3.3	... location of friendly units with respect to terrorist unit					Not used in scenario
5.3.4	... countermeasures available to friendly units					Not used in scenario
5.3.5	... risk to friendly units					Not used in scenario
5.3.6	... value of friendly units					Not used in scenario
5.3.7	... possibility of unknown terrorist units nearby					Not used in scenario
5.3.8	... risk to neutral units		Risk	TACNAV	6	
5.4	... immediateness of the threat					
5.4.1	... overt posture of the terrorist unit					Not used in scenario
5.4.2	... time required to activate terrorist weapons					Not used in scenario
5.4.3	... distance of terrorist unit to nearest friendly unit					Not used in scenario
5.4.4	... length of time to strike					Not used in scenario
5.4.5	... probable stress of terrorist crew					Not used in scenario
5.4.6	... possible rationale for engagement by terrorist unit					Not used in scenario
5.5	... optimum counter to terrorist threat					
5.5.1	... list of available units to counter to terrorist threat					Not used in scenario
5.5.2	... selection of best units to counter to terrorist threat		Units	TACNAV	5 to 18	
5.5.3	... list of available defensive system(s)					Not used in scenario
5.5.4	... selection of best defensive system(s)					Not used in scenario

Table C-6 Top Down Goal Analysis – Goal 5 … reaction to a terrorist threat

Number	Level 1 2 3 4 5 Goal/Objective and Subgoals/Subobjectives	IAI Candidate	Influenced Variable	Assignment	Completion Time (Sec)	Notes
5.5.5	... list of available offensive system(s)					Not used in scenario
5.5.6	... selection of best offensive system(s)		System	TACNAV	5 to 20	
5.6	... implementation of counter to threat					
5.6.1	... plan of action prepared for all available units					Not used in scenario
5.6.2	... tasking message produced for each unit					Not used in scenario
5.6.3	... tasking message has been transmitted		Message transmitted	TACNAV	6 to 9	Similar to 3.3.4
5.6.4	... tasking message has been acknowledged		Message acknow-ledged	UAV Op	9	Similar to 3.3.5
5.7	... follow-up after threat is neutralized					
5.7.1	... terrorist unit battle damage video collection is planned					Not used in scenario
5.7.2	... collection of battle damage video					Not used in scenario Following the launch of a UAV
5.7.3	... analysis of battle damage video					Not used in scenario
5.7.4	... reassessment of risk to friendly units					Not used in scenario Similar to 5.3.5
5.7.5	... assessment of requirement for search and rescue					Not used in scenario

Table C-6 Top Down Goal Analysis – Goal 5 … reaction to a terrorist threat

Number	Level 1 2 3 4 5	Goal/Objective and Subgoals/Subobjectives	IAI Candidate	Influenced Variable	Assignment	Completion Time (Sec)	Notes
5.7.6		... tracking of terrorist unit					Not used in scenario
5.7.7		... monitoring of terrorist unit activities					Not used in scenario
5.7.8		… damage report provided to friendly unit		Report provided	TACNAV	8	

Table C-7 Top Down Goal Analysis – Goal 6 … tactical mission planning is conducted

Number	Level Goal/Objective and Subgoals/Subobjectives 1 2 3 4 5	IAI Candidate	Influenced Variable	Assignment	Completion Time (Sec)	Notes
Top	I want to perceive the (...) conduct of the terrorist patrol mission					
6	**… tactical mission planning is conducted**					
6.1	... terrorist objectives are determined					Not used in scenario
6.2	... terrorist resources are estimated					
6.2.1	… information on the potential threat is collected					Not used in scenario
6.3	... terrorist plan is deduced					Not used in scenario
6.4	... terrorist's potential location					
6.4.1	... the probable position of the terrorist vessel		Position	TACNAV	5 to 30	
6.4.2	... an area contains a contact being sought					Not used in scenario
6.4.3	... an area does not contain a contact being sought					Not used in scenario
6.4.4	... search area is appropriate for the current situation		Area	TACNAV	15	
6.4.5	…display area on workstation is appropriate		Area	TACNAV	12	
6.5	... number and type of current assets					Not used in scenario

Table C-7 Top Down Goal Analysis – Goal 6 … tactical mission planning is conducted

Number	Level 1 2 3 4 5 Goal/Objective and Subgoals/Subobjectives	IAI Candidate	Influenced Variable	Assignment	Completion Time (Sec)	Notes
6.6	... location of current assets					Not used in scenario
6.7	... plan to counter potential terrorist activities					
6.7.1	… alternatives to finding terrorist boat					Not used in scenario
6.7.2	… alternatives to counter potential terrorist activities					Not used in scenario
6.8	... contingency plans are created					
6.8.1	... the need for contingency plans is addressed		Need for plans	TACNAV	30	
6.8.2	... contingency plans are created		Plans	TACNAV	10	
6.8.3	... contingency plans are discussed		Plans	TACNAV	10	
6.8.4	... contingency plans are assessed					Not used in scenario
6.8.5	... contingency plans are revised					Not used in scenario
6.9	... UAV piloting aspects are studied					
6.9.1	... VTUAV piloting aspects are studied		Piloting aspects	UAV Plt	20	
6.9.2	... MALE UAV piloting aspects are studied					Not used in scenario
6.9.3	... Mini UAV piloting aspects are studied					Not used in scenario
6.10	... alternative techniques to find lost contact		Techniques	TACNAV	20	

Table C-8 Top Down Goal Analysis – Goal 7 … UAVs are employed

Number	Level 1 2 3 4 5 Goal/Objective and Subgoals/Subobjectives	IAI Candidate	Influenced Variable	Assignment	Completion Time (Sec)	Notes
Top	I want to perceive the (...) conduct of the terrorist patrol mission					
7	**… UAVs are employed**					
7.1	... VTUAV is employed					
7.1.1	... VTUAV navigation is conducted					
7.1.1.1	... VTUAV route to the next operating area is planned	Yes	Route	UAV Plt	5 to 30	
7.1.1.2	... VTUAV search pattern is planned					
7.1.1.2.1	... selection of an appropriate search pattern	Yes	Pattern	UAV Plt	7 to 15	
7.1.1.2.2	... VTUAV expanding square search is planned					Not used in scenario
7.1.1.2.3	... VTUAV creeping line advance search is planned					Not used in scenario
7.1.1.2.4	... VTUAV track crawl search is planned					Not used in scenario
7.1.1.2.5	... VTUAV sector search is planned					Not used in scenario
7.1.1.2.6	... VTUAV random search is planned					Not used in scenario
7.1.1.2.7	... location of contact symbol is determined on tacplot		Location	UAV Plt	8	
7.1.1.2.8	... direction of movement of contact symbol		Direction	UAV Op	3	

Table C-8 Top Down Goal Analysis – Goal 7 … UAVs are employed

Number	Level 1 2 3 4 5	Goal/Objective and Subgoals/Subobjectives	IAI Candidate	Influenced Variable	Assignment	Completion Time (Sec)	Notes
7.1.1.3		... VTUAV waypoint is inserted	Yes	Waypoint	TACNAV	3 to 15	
7.1.1.4		... VTUAV endurance is calculated					Not used in scenario
7.1.1.5		... VTUAV destination is determined					Not used in scenario
7.1.1.6		... VTUAV time on task is calculated					
7.1.1.6.1		... location of potential VTUAV refuelling platforms		Location	UAV Plt	20	
7.1.1.6.2		... estimated CPF location at time off task		Location	UAV Plt	8	
7.1.1.6.3		... VTUAV fuel on board and average fuel flow		Fuel quantity	UAV Plt	5	
7.1.1.6.4		... rough VTUAV time on task is calculated		Time	UAV Plt	4	
7.1.1.6.5		... precise VTUAV time on task is calculated	Yes	Time	UAV Plt	10 to 20	
7.1.1.6.6		... any problems associated with refuelling		Problems	UAV Plt	10	
7.1.1.7		... VTUAV search datum is inserted					Not used in scenario
7.1.1.8		... VTUAV activities are planned		Activities	TACNAV	10	
7.1.1.9		... VTUAV planning activities are monitored		Activities monitored	UAV Plt	10	
7.1.1.10		... VTUAV route is plotted	Yes	Route	UAV Plt	12	
7.1.1.11		... handover of VTUAV has been prepared		Handover	TACNAV	7	
7.1.2		... VTUAV flight path is controlled					
7.1.2.1		... VTUAV heading has changed to a new heading	Yes	Heading	UAV Plt	5 to Cont.	
7.1.2.2		... VTUAV altitude has changed to a new altitude		Altitude	UAV Plt	5 to 6	
7.1.2.3		... VTUAV speed has changed to a new speed					Not used in scenario
7.1.2.4		... VTUAV autopilot set to autonomous mode		Mode	UAV Plt	4	

Table C-8 Top Down Goal Analysis – Goal 7 … UAVs are employed

Number	Level 1 2 3 4 5 Goal/Objective and Subgoals/Subobjectives	IAI Candidate	Influenced Variable	Assignment	Completion Time (Sec)	Notes
7.1.2.5	... VTUAV transitions to a hover		Flight parameters	UAV Plt	5	
7.1.3	... VTUAV flight path is monitored	Yes	Path	UAV Plt	4 to Cont.	
7.1.4	... VTUAV EO sensors are configured					
7.1.4.1	... VTUAV EO sensor settings are optimized	Yes	Settings	UAV Op	6 to 30	
7.1.4.2	... VTUAV EO sensor is used for a test observation		Test observation	UAV Op	10	
7.1.5	... VTUAV EO sensor is employed					
7.1.5.1	... VTUAV EO sensor is used to search for contact	Yes	Sensor used	UAV Op	4 to Cont.	When CP140 controls VTUAV
7.1.5.2	... VTUAV EO sensor is used to study a contact	Yes	Sensor used	UAV Op	4 to Cont.	When contact is found
7.1.5.3	... VTUAV EO sensor is used to track a contact					Not used in scenario After contact has been identified
7.1.5.4	... VTUAV EO zoomed in on a portion of boat	Yes	Zoom ratio	UAV Op	7	
7.1.5.5	... VTUAV EO used to record images of contact	Yes	Record	UAV Op	12 to Cont.	
7.1.5.6	... VTUAV EO images are monitored		Images monitored	UAV Plt	25	
7.1.5.7	... VTUAV EO image file is stowed		File stowed	UAV Op	10	
7.1.6	... VTUAV radar is configured					
7.1.6.1	... VTUAV radar settings are optimized					Not used in scenario
7.1.6.2	... VTUAV radar is used for a test observation					Not used in scenario

Table C-8 Top Down Goal Analysis – Goal 7 … UAVs are employed

Number	Level 1 2 3 4 5 Goal/Objective and Subgoals/Subobjectives	IAI Candidate	Influenced Variable	Assignment	Completion Time (Sec)	Notes
7.1.7	... VTUAV radar is employed					
7.1.7.1	... VTUAV radar is used to search for lost contact		Radar return	UAV Op	14 to 60	
7.1.7.2	... VTUAV radar is used to vector another asset					
7.1.7.3	... VTUAV radar is used to GENTRACK contact		GENTRACK	UAV Op	4 to 10	
7.1.8	... VTUAV expert system is tasked					Not used in scenario
7.1.9	... VTUAV systems are monitored and managed					
7.1.9.1	... VTUAV data up-link is maintained	Yes	Data uplink	UAV Op	12 to Cont.	
7.1.9.2	... initial system checks on VTUAV are conducted	Yes	Checks	UAV Plt	12 to 30	
7.1.9.3	... initial system settings on VTUAV are reviewed		Settings	UAV Op	10	
7.1.9.4	... VTUAV systems are monitored	Yes	Systems monitored	UAV Plt	6 to Cont.	
7.1.9.5	... VTUAV systems are managed					Not used in scenario
7.1.9.6	... VTUAV systems are failing		Systems status	UAV Op	2 to 3	
7.1.9.7	... VTUAV systems are analysed					Not used in scenario
7.2	... MALE UAV is employed					
7.2.1	... MALE UAV navigation is conducted		Navigation	TACNAV	9 to 12	
7.2.2	... MALE UAV flight path is controlled					Not used in scenario
7.2.3	... MALE UAV flight path is monitored					Not used in scenario

Table C-8 Top Down Goal Analysis – Goal 7 … UAVs are employed

Number	Level 1 2 3 4 5 Goal/Objective and Subgoals/Subobjectives	IAI Candidate	Influenced Variable	Assignment	Completion Time (Sec)	Notes
7.2.4	... MALE UAV radar is configured					Not used in scenario
7.2.4.1	... MALE UAV radar settings are optimized					Not used in scenario Similar to 7.1.6.1
7.2.4.2	... MALE UAV radar is used for a test observation					Not used in scenario Similar to 7.1.6.2
7.2.5	... MALE UAV radar is employed					
7.2.5.1	... MALE UAV radar is used to search for lost contact					Not used in scenario Similar to 7.1.7.1
7.2.5.2	... MALE UAV radar is used to vector another asset					Not used in scenario Similar to 7.1.7.2
7.2.5.3	... MALE UAV radar is used for ISAR imaging					Not used in scenario
7.2.6	... MALE UAV expert system is tasked					Not used in scenario Similar to 7.1.8
7.2.7	... MALE UAV systems are monitored and managed					
7.2.7.1	... MALE UAV data up-link is maintained					Not used in scenario Similar to 7.1.9.1
7.2.7.2	... initial system checks on MALE UAV are conducted					Not used in scenario Similar to 7.1.9.2
7.2.7.3	... initial system settings on MALE UAV are reviewed					Not used in scenario Similar to 7.1.9.3
7.2.7.4	... MALE UAV systems are monitored					Not used in scenario Similar to 7.1.9.4
7.2.7.5	... MALE UAV systems are managed					Not used in scenario Similar to 7.1.9.5

Table C-8 Top Down Goal Analysis – Goal 7 … UAVs are employed

Number	Level 1 2 3 4 5 Goal/Objective and Subgoals/Subobjectives	IAI Candidate	Influenced Variable	Assignment	Completion Time (Sec)	Notes
7.3	... Mini UAV is employed					
7.3.1	... Mini UAV navigation is conducted					
7.3.1.1	... Mini UAV route to the next operating area is planned					Not used in scenario
7.3.1.2	... Mini UAV search pattern is planned	Yes	Pattern	TACNAV	5 to 15	
7.3.1.3	... Mini UAV waypoint is inserted	Yes	Waypoint	TACNAV	3 to 10	
7.3.1.4	... Mini UAV endurance is calculated					Not used in scenario
7.3.1.5	... Mini UAV time on task is calculated					Not used in scenario
7.3.1.6	... Mini UAV search datum is inserted					Not used in scenario
7.3.1.7	... Mini UAV planning activities are monitored					Not used in scenario
7.3.1.8	... Mini UAV route is plotted	Yes	Route	UAV Plt	10 to 18	
7.3.1.9	... Mini UAV deployment symbol located on surface plot					Not used in scenario
7.3.1.10	... crew is briefed on use of Mini UAVs	Yes	Briefing conducted	TACNAV	18 to 20	
7.3.1.11	... crew have been requested to launch Mini UAV		Crew directed	TACNAV	8	
7.3.1.12	... Mini UAV opening height is set		Height	TACNAV	7	
7.3.2	... Mini UAV flight path is controlled					
7.3.2.1	... Mini UAV heading has changed to a new heading	Yes	Heading	UAV Plt	6 to 8	
7.3.2.2	... Mini UAV altitude has changed to a new altitude	Yes	Altitude	UAV Plt	22	
7.3.2.3	... Mini UAV speed has changed to a new speed					Not used in scenario

Table C-8 Top Down Goal Analysis – Goal 7 … UAVs are employed

Number	Level 1 2 3 4 5	Goal/Objective and Subgoals/Subobjectives	IAI Candidate	Influenced Variable	Assignment	Completion Time (Sec)	Notes
7.3.2.4		... Mini UAV altitude change has been initiated		Change initiated	UAV Plt	6 to 8	
7.3.2.5		... Mini UAV automatic over-flight function is initiated	Yes	Overflight initiated	UAV Op	6 to 10	
7.3.2.6		... Mini UAV is set to autonomous operations	Yes	Setting	UAV Op	7 to 45	
7.3.2.7		... Mini UAV initiates a pre-planned route about a contact	Yes	Route planned	UAV Plt	5 to 8	
7.3.2.8		... Mini UAV initiates a self-destruct manoeuvre	Yes	Manoeuvre initiated	UAV Plt	6	
7.3.2.9		... manual control of Mini UAV is initiated		Control initiated	UAV Plt	4	
7.3.2.10		... Mini UAV is manoeuvring about contact	Yes	Position	UAV Plt	14 to Cont.	
7.3.3		... Mini UAV flight path is monitored					
7.3.3.1		... Mini UAV symbol has appeared on the surface plot	Yes	Symbol	TACNAV	2 to 23	
7.3.3.2		... Mini UAV is in descent following deployment		Height	UAV Plt	5	
7.3.3.3		... Mini UAV is following the planned flight path	Yes	Position	UAV Plt	Cont.	
7.3.3.4		... Mini UAV is establishing level flight	Yes	Altitude	UAV Plt	5 to 6	
7.3.3.5		... Mini UAV is autonomously following contact		Position	TACNAV	13	
7.3.4		... Mini UAV EO sensors are configured					
7.3.4.1		... Mini UAV EO sensor settings are optimized	Yes	Settings	UAV Op	10	
7.3.4.2		... Mini UAV EO sensor is used for a test observation					Not used in scenario
7.3.5		... Mini UAV EO sensors are employed					

Table C-8 Top Down Goal Analysis – Goal 7 … UAVs are employed

Number	Level 1 2 3 4 5 Goal/Objective and Subgoals/Subobjectives	IAI Candidate	Influenced Variable	Assignment	Completion Time (Sec)	Notes
7.3.5.1	... Mini UAV EO sensor is used to search for lost contact					Not used in scenario Prior to finding contact
7.3.5.2	... Mini UAV EO sensor is used to study a contact		Contact	UAV Op	4 to Cont.	
7.3.5.3	... Mini UAV EO sensor is used to track a contact					Not used in scenario After contact has been identified
7.3.5.4	... Mini UAV EO zoomed in on a portion of boat		Zoom ratio	UAV Op	12	Same as 7.1.5.4
7.3.5.5	... Mini UAV EO used to read images of contact					Not used in scenario Same as 7.1.5.5
7.3.5.6	... Mini UAV EO sensor is used to track a contact	Yes	Position	UAV Op	14 to 20	Same as 7.1.5.6
7.3.5.7	... Mini UAV EO is used to record high definition images	Yes	Recording	UAV Op	8 to15	
7.3.5.8	... Mini UAV FOV trapezoid is over contact	Yes	Position	UAV Op	5	
7.3.5.9	... Mini UAV EO video recording is operating	Yes	Video operating	UAV Op	9	
7.3.5.10	... EO images are organized on desktop		Images organized	TACNAV	Cont.	
7.3.6	... Mini UAV expert system is tasked					Not used in scenario
7.3.7	... Mini UAV systems are monitored and managed					
7.3.7.1	... Mini UAV data up-link is maintained					Not used in scenario
7.3.7.2	... initial system checks on Mini UAV are conducted		Checks	UAV Plt	4	
7.3.7.3	... Mini UAV systems are monitored	Yes	Systems monitored	UAV Plt	9 to Cont.	
7.3.7.4	... Mini UAV systems are managed		Systems managed	UAV Plt	5	

Table C-8 Top Down Goal Analysis – Goal 7 … UAVs are employed

Number	Level 1 2 3 4 5 Goal/Objective and Subgoals/Subobjectives	IAI Candidate	Influenced Variable	Assignment	Completion Time (Sec)	Notes
7.3.7.5	... Mini UAV image file is stowed	Yes	Files stowed	UAV Op	14	
7.3.8	... Mini UAV video playback is analysed					
7.3.8.1	... previous minutes of video are reviewed		Images reviewed	TACNAV	20	

Table C-9 Top Down Goal Analysis – Goal 8 … CP140 terrorist patrol navigation is conducted

Number	Level 1 2 3 4 5 Goal/Objective and Subgoals/Subobjectives	IAI Candidate	Influenced Variable	Assignment	Completion Time (Sec)	Notes
Top	I want to perceive the (...) conduct of the terrorist patrol mission					
8	**… CP140 terrorist patrol navigation is conducted**					
8.1	... CP140 route to the next operating area is planned					
8.1.1	... radar update of surface plot is received		Plot received	TACNAV	4	
8.1.2	... optimal route to the next operating area		Route	TACNAV	5	
8.1.3	... overall plan for use of the CP140		Plan	TACNAV	14	
8.2	... CP140 search pattern is planned					Not used in scenario
8.3	... CP140 waypoint is inserted					
8.3.1	... contact waypoint (or datum) is provided to the flight crew					Not used in scenario
8.3.2	... holding waypoint is provided to the flight crew		Waypoint	TACNAV	7	
8.3.3	... en route waypoint is provided to the flight crew					Not used in scenario
8.3.4	... translating waypoint is provided to the flight crew					Not used in scenario
8.4	... CP140 endurance is calculated					Not used in scenario

Table C-9 Top Down Goal Analysis – Goal 8 … CP140 terrorist patrol navigation is conducted

Number	Level 1 2 3 4 5 Goal/Objective and Subgoals/Subobjectives	IAI Candidate	Influenced Variable	Assignment	Completion Time (Sec)	Notes
8.5	... CP140 destination is determined					Not used in scenario
8.6	... CP140 time on task is calculated					Not used in scenario
8.7	... flight crew are provided flight directions					
8.7.1	... flight crew are requested to change heading	Yes	Change requested	TACNAV	3 to- 5	
8.7.2	... flight crew are requested to change altitude		Change requested	TACNAV	7	
8.7.3	... flight crew are requested to change speed	Yes	Change requested	TACNAV	5	
8.7.4	... flight crew are provided necessary supplemental info					Not used in scenario
8.8	... CP140 intercept to observe contact is planned					Not used in scenario
8.9	... CP140 flight path is appropriate for mission related activities					
8.9.1	... CP140 is in a position of observe visual contact					Monitor task
8.9.2	... CP140 is outside possible threat envelopment					Monitor task
8.9.3	... CP140 is at an altitude to maintain radar contact	Yes	Altitude	TACNAV	3 to 10	
8.9.4	... CP140 is positioning for Mini UAV deployment		Position	TACNAV	4	

Table C-9 Top Down Goal Analysis – Goal 8 … CP140 terrorist patrol navigation is conducted

Number	Level 1 2 3 4 5	Goal/Objective and Subgoals/Subobjectives	IAI Candidate	Influenced Variable	Assignment	Completion Time (Sec)	Notes
8.9.5		... CP140 is holding following UAV deployment					Not used in scenario
8.9.6		... CP140 is en route tactical waypoint		Position	TACNAV	3	

Table C-10 Top Down Goal Analysis – Goal 9 … communications are maintained

Number	Level Goal/Objective and Subgoals/Subobjectives 1 2 3 4 5	IAI Candidate	Influenced Variable	Assignment	Completion Time (Sec)	Notes
Top	I want to perceive the (...) conduct of the terrorist patrol mission					
9	**... communications are conducted and maintained**					
9.1	... directions (instructions) are received					
9.1.1	... directions are received from other crew members	Yes	Directions	UAV Plt	4 to 25	
9.1.2	... directions are received from other units	Yes	Directions	UAV Plt	5 to 14	
9.1.3	... directions are received from tasking agency		Directions	TACNAV	20	
9.2	... information is received					
9.2.1	... information is received from other crew members					
9.2.1.1	... visual contact is established by flight crew					Not used in scenario
9.2.1.2	... VTUAV refuelling location		Location	TACNAV	5	
9.2.1.3	... VTUAV calculated time on task	Yes	Time	TACNAV	5	
9.2.1.4	... the flight crew's message that contact is identified		Message contents	UAV Op	5	
9.2.1.5	... the pilot's message that ac is turning to waypoint					Not used in scenario

Table C-10 Top Down Goal Analysis – Goal 9 … communications are maintained

Number	Level 1 2 3 4 5 Goal/Objective and Subgoals/Subobjectives	IAI Candidate	Influenced Variable	Assignment	Completion Time (Sec)	Notes
9.2.1.6	... information disseminated to other crew members	Yes	Information	UAV Op	3 to 15	
9.2.1.7	... information relating to sensor data collection	Yes	Information	TACNAV	3 to 24	
9.2.1.8	... aircraft specific information relevant to mission	Yes	Information	TACNAV	3 to 9	
9.2.1.9	... information relating to deployment of Mini UAV(s)					Not used in scenario
9.2.1.10	... information of a general nature	Yes	Information	UAV Plt	3 to 35	
9.2.2	... information is received from other units					
9.2.2.1	... ROC surface plot arrival time delay					Not used in scenario
9.2.2.2	... time till handover of VTUAV		Time	TACNAV	13	
9.2.2.3	... information of a general nature	Yes	Information	TACNAV	5 to 16	
9.2.3	... information is received from tasking agency		Information	UAV Op	20	
9.2.4	... information is received from ROC		Information	UAV Op	6 to 15	
9.3	... transmission of directions (instructions)					
9.3.1	... directions are transmitted to other crew members	Yes	Directions	TACNAV	4 to 25	
9.3.2	... directions are transmitted to other units					Not used in scenario
9.3.2.1	... request for surface plot is passed to Cape Race					Not used in scenario
9.3.2.2	... request for surface plot is passed to ROC		Request passed	TACNAV	5	
9.3.2.3	... fighter aircraft are directed to attack threat		Direction passed	TACNAV	14	

Table C-10 Top Down Goal Analysis – Goal 9 … communications are maintained

Number	Level 1 2 3 4 5 Goal/Objective and Subgoals/Subobjectives	IAI Candidate	Influenced Variable	Assignment	Completion Time (Sec)	Notes
9.3.3	... directions are transmitted to tasking agency					Not used in scenario
9.3.4	... all radio transmissions are secure, full EW policies		Transmission mode	TACNAV	5	
9.4	... transmission of information					
9.4.1	... information is transmitted to other crew members					
9.4.1.1	... VTUAV refuelling location is transmitted		Location transmitted	UAV Plt	5	
9.4.1.2	... VTUAV calculated time on task is transmitted	Yes	Time transmitted	UAV Plt	5	
9.4.1.3	... identification and activities of contact	Yes	Identification	UAV Op	3 to 20	
9.4.1.4	... specific information regarding a UAV	Yes	Information	UAV Plt	3 to 20	
9.4.1.5	... information of a general nature		Information	TACNAV	3 to 35	
9.4.2	... information is transmitted to other units					Not used in scenario
9.4.3	... information is transmitted to tasking agency					Not used in scenario

Table C-11 Top Down Goal Analysis – Goal 10 … systems are monitored and managed

Number	Level 1 2 3 4 5 Goal/Objective and Subgoals/Subobjectives	IAI Candidate	Influenced Variable	Assignment	Completion Time (Sec)	Notes
Top	I want to perceive the (...) conduct of the terrorist patrol mission					
10	**... systems are monitored and managed**					
10.1	... personnel are available for monitoring and managing subsystems					
10.1.1	... tactical crew are organized					
10.1.1.1	... ASOs have been asked to move to the galley		Location	TACNAV	2	
10.1.1.2	... UAV Op has taken the ASO 2 position		Location	UAV Op	2	
10.1.1.3	... NAVCOM is prepared for UAV mission		State	TACNAV	2	
10.1.1.4	... CP140 third pilot has taken the ASO 1 position		Location	UAV Plt	2 to 20	
10.1.1.5	... equipment from the previous activity is stowed		Location	TACNAV	5	
10.1.2	... tactical crew workstations are configured					
10.1.2.1	... TACNAV workstation is configured		Configuration status	TACNAV	10	
10.1.2.2	... UAV Plt workstation is configured		Configuration status	UAV Plt	10	
10.1.2.3	... UAV Op workstation is configured		Configuration status	UAV Op	10	
10.1.2.4	... NAVCOM workstation is configured					Not used in scenario

Table C-11 Top Down Goal Analysis – Goal 10 … systems are monitored and managed

Number	Level 1 2 3 4 5 Goal/Objective and Subgoals/Subobjectives	IAI Candidate	Influenced Variable	Assignment	Completion Time (Sec)	Notes
10.2	... multifunction workstation are monitored and managed					
10.2.1	... multifunction workstations are monitored					Not used in scenario
10.2.2	... multifunction workstations are managed					Not used in scenario
10.3	... data links are maintained					
10.3.1	... data link with the VTUAV is maintained					Not used in scenario
10.3.2	... data link with the MALE UAV is maintained					Not used in scenario
10.3.3	... data link with the Mini UAV is maintained					Not used in scenario
10.4	... countermeasures are monitored and managed					
10.4.1	... countermeasures are monitored					
10.4.1.1	... EW countermeasures are monitored					Not used in scenario
10.4.1.2	... anti-missile countermeasures are monitored					Not used in scenario
10.4.2	... countermeasures are managed					
10.4.2.1	... EW countermeasures are managed					Not used in scenario
10.4.2.2	... anti-missile countermeasures are managed					Not used in scenario
10.4.3	... countermeasures are configured					
10.4.3.1	... EW countermeasures are configured					Not used in scenario
10.4.3.2	... anti-missile countermeasures are configured					Not used in scenario

Table C-11 Top Down Goal Analysis – Goal 10 … systems are monitored and managed

Number	Level 1 2 3 4 5 Goal/Objective and Subgoals/Subobjectives	IAI Candidate	Influenced Variable	Assignment	Completion Time (Sec)	Notes
10.5	... sonobouy launchers are monitored and managed					
10.5.1	... sonobouy launchers are monitored					Not used in scenario
10.5.2	... sonobouy launchers are managed					Not used in scenario

C.2.1 Bottom Up Goal Analysis (Part 1 Of Scenario – First 20 Minutes)

I want to perceive (that) (the) ...

Part 1-1 ... preparations for tasking are being conducted

153 ... tactical crew reorganized
154 ... crew workstations configured
144 ... UAV crew taking control of the VTUAV
159 ... terrorist mission tasking acknowledged
150 ... threat is assessed
246 ... estimate of VTUAV time on task

Part 1-2 ... UTUAV operations are conducted (search for terrorist boat)

140 ... VTUAV route planned to next contact
212 ... VTUAV route initiated by UAV crew
282 ... the expected location for contact is searched
296 ... investigation of Contact 2
294 ... updated surface plot is requested
374 ... Contact 2 located on the VTUAV radar
376 ... VTUAV route initiated and flown
386 ... Contact 2 is identified using the VTUAV EO
400 ... the target of opportunity is investigated
456 ... terrorist mission planning with the ROC
452 ... VTUAV tracking towards the waypoint
470 ... VTUAV route initiated and flown
486 ... VTUAV refuelling is planned

Part 1-3 ... CP140 operations are conducted (search for terrorist boat)

142 ... CP140 route planned to next contact
170 ... CP140 is en route to contact
234 ... CP140 approaching and identifying Contact 4
274 ... CP140 is en route to Contact 4
340 ... Mini UAV prepared for release over Contact 4
416 ... surface plot updated using the CP140 radar

Second and third level goals are listed below in the order that they appear in the network, not in the order listed above. Each line contains the OSD task number, a two-letter designator for the operator (TN=TACNAV; UO=UAV Operator; UP=UAV Pilot; CR=CP140 Crew; OU=Other Units), task description (OSD label), task completion time and corresponding top down goal number.

Task OSD No.	Operator	Task	Completion Time	Top Down HGA Cross-Reference No.
		--- 153 … tactical crew reorganized ---		
153	TN	Stow equipment from previous activity	5 Sec	10.1.1.5
124	TN	Request that ASOs move to the galley	2 Sec	10.1.1.1
128	TN	Request that the UAV Op take the ASO 1 position	2 Sec	10.1.1.2
130	UO	Receive request to take the ASO 1 position	2 Sec	10.1.1.2
131	UO	Strap into ASO 1 seat	20 Sec	10.1.1.2
132	TN	Request that the NAVCOM prepare for the UAV mission	2 Sec	10.1.1.3
134	CR	(NAVCOM) Receive request		N/A
135	CR	Stow equipment from previous activity	5 Sec	N/A
136	TN	Request that the UAV Plt take the ASO 2 position	2 Sec	10.1.1.4
138	UP	Receive request to take the ASO 2 position	2 Sec	10.1.1.4
139	UP	Strap into ASO 2 seat	20 Sec	10.1.1.4
		--- 154 ... crew workstations configured ---		
154	TN	Configure TACNAV workstation	10 Sec	10.1.2.1
156	UO	Configure the UAV Op (ASO 1) workstation	10 Sec	10.1.2.3
158	CR	(NAVCOM) Configure the NAVCOM workstation	10 Sec	N/A
160	UP	Configure the UAV Plt (ASO 2) workstation	10 Sec	10.1.2.2
		--- 144 ... UAV crew taking control of the VTUAV ---		
144	UO	Establish data link with VTUAV 1	13 Sec	7.1.9.1
145	UO	Maintain data link with VTUAV 1	Cont.	7.1.9.1
146	UP	Conduct initial system checks on VTUAV using a checklist	30 Sec	7.1.9.2
148	UO	Optimize VTUAV EO sensors	30 Sec	7.1.4.1

Task OSD No.	Operator	Task	Completion Time	Top Down HGA Cross-Reference No.
162	UP	Maintain VTUAV track towards a CPF established waypoint	Cont.	7.1.3
164	UP	Review CPF established parameters for VTUAV	10 Sec	7.1.9.3
166	UO	Review CPF established parameters for VTUAV	10 Sec	7.1.9.3
168	UO	Conduct test observation of contact in direction of flight	10 Sec	7.1.4.2
204	UP	Study the UAV piloting aspects of the current situation	20 Sec	6.9.1
		--- 140 ... VTUAV route planned to next contact ---		
140	TN	Plan VTUAV route to the next operating area	20 Sec	7.1.1.1
208	TN	Establish an intercept point for Contact 2	15 Sec	7.1.1.3
210	TN	Plan the VTUAV activities at Contact 2 location	10 Sec	7.1.1.8
221	UO	Plan the VTUAV activities at Contact 2 location	10 Sec	7.1.1.8
223	UP	Monitor planning	10 Sec	7.1.1.9
		--- 159 ... terrorist mission tasking acknowledged ---		
159	CR	(NAVCOM) Review tasking		N/A
199	CR	(NAVCOM) Transmit tasking acknowledgement	5 Sec	N/A
200	TN	Monitor acknowledgement	5 Sec	9.2.2.3
201	OU	(Tasking Agency) Receive tasking acknowledgement	5 Sec	N/A
202	TN	Monitor the establishment of tactical radio nets	30 Sec	9.4.2
203	CR	(NAVCOM) Establish tactical radio nets	30 Sec	N/A
205	UP	Monitor acknowledgement	5 Sec	9.2.2.3
207	UO	Monitor acknowledgement	5 Sec	9.2.2.3

Task OSD No.	Operator	Task	Completion Time	Top Down HGA Cross-Reference No.
209	UP	Monitor the establishment of tactical radio nets	30 Sec	9.4.2
211	UO	Monitor the establishment of tactical radio nets	30 Sec	9.4.2
213	OU	Establish tactical radio nets with the CP140	30 Sec	9.4.2
		--- 142 ... CP140 route planned to next contact ---		
142	TN	Plan CP140 route to the next operating area	5 Sec	8.1.2
		--- 150 ... threat is assessed ---		
150	TN	Create contingency plans	10 Sec	6.8.2
151	TN	Discuss contingency plans	10 Sec	6.8.3
152	TN	Review rules of engagement	8 Sec	5.1.3
155	CR	(NAVCOM) Discuss contingency plans	10 Sec	N/A
238	CR	Collect information on the potential threat	30 Sec	N/A
240	CR	Configure the CP140 countermeasures	10 Sec	N/A
		--- 246 ... estimate of VTUAV time on task ---		
246	UP	Produce rough estimate of the VTUAV time on task	4 Sec	7.1.1.6.4
247	UP	Find potential VTUAV refuelling platforms	20 Sec	7.1.1.6.1
248	UP	Advise that fuelling location for the VTUAV is the CPF	5 Sec	9.4.1.1
250	TN	Receive message	5 Sec	9.2.1.2
252	UO	Receive message	5 Sec	9.2.1.2
254	UP	Estimate CPF location at maximum time on task	8 Sec	7.1.1.6.2
256	UP	Determine VTUAV fuel on board and fuel flow	5 Sec	7.1.1.6.3
258	UP	Calculate time on task	10 Sec	7.1.1.6.5
260	UP	Advise the crew of VTUAV calculated time on task	5 Sec	9.4.1.2

Task OSD No.	Operator	Task	Completion Time	Top Down HGA Cross-Reference No.
262	TN	Receive message	5 Sec	9.2.1.3
264	UO	Receive message	5 Sec	9.2.1.3
266	CR	(Crew) Receive message	5 Sec	N/A
		--- 212 ... VTUAV route initiated by UAV crew ---		
212	TN	Request VTUAV heading, altitude and speed change	5 Sec	9.3.1
214	UP	Receive request for VTUAV heading, alt. and speed change	5 Sec	9.1.2
215	TN	Request EO Observation of Contact 2 using VTUAV	5 Sec	9.3.1
216	UO	Monitor request	5 Sec	9.2.1.6
217	UP	Receive request to observe Contact 2	5 Sec	9.3.1
218	UP	Change VTUAV heading, altitude and speed	20 Sec	7.1.2.1
219	UO	Receive request to observe Contact 2	5 Sec	9.3.1
220	UP	Maintain VTUAV track towards intercept point for Contact 2	Cont	7.1.3
222	UO	Use VTUAV radar to search for Contact 2	60 Sec	7.1.7.1
224	UO	Use VTUAV EO to search for Contact 2	60 Sec	7.1.5.1
		--- 170 ... CP140 is enroute to contact ---		
170	TN	Provide AC with waypoint for Contact 1 and request turn	3 Sec	8.7.1
172	CR	(AC) Receive request	3 Sec	N/A
174	UO	Monitor request	3 Sec	8.7.1
176	UP	Monitor request	3 Sec	8.7.1
178	TN	Request speed increase and descent to 500 ft	5 Sec	8.7.3
180	CR	(AC) Receive request	5 Sec	N/A
182	UO	Monitor request	5 Sec	8.7.3

Task OSD No.	Operator	Task	Completion Time	Top Down HGA Cross-Reference No.
184	UP	Monitor request	5 Sec	8.7.3
186	TN	Request that Contact 1 be approached with caution	5 Sec	9.3.1
188	CR	(AC) Receive request	5 Sec	N/A
190	UO	Monitor request	5 Sec	9.2.1.10
192	UP	Monitor request	5 Sec	9.2.1.10
194	TN	Monitor the NASO 1 activities to clear the descent	10 Sec	2.7.1.1
196	TN	Monitor the NASO 1 activities to generate GENTRACK	10 Sec	2.7.1.2
198	TN	Monitor the NASO 2 activities to configure the onboard EO	10 Sec	2.7.1.3
206	CR	(Flight Crew) Visually search for Contact 1	Cont.	N/A
		--- 282 ... the expected location for contact is searched ---		
282	UO	Establish updated surface plot around the datum for Contact 2	15 Sec	4.1.5
350	UO	Locate possible terrorist boat (Contact 2) on VTUAV radar	10 Sec	4.3.1
351	UO	Start GENTRACK of possible terrorist boat	Cont.	7.1.7.3
352	UP	Turn VTUAV to investigate Contact 2	5 Sec	7.1.2.1
354	UP	Maintain VTUAV track towards Contact 2	Cont.	7.1.3
		--- 234 ... CP140 approaching and identifying Contact 4 ---		
226	CR	(NASO2) Report that EO contact has been established	3 Sec	N/A
228	TN	Receive message	3 Sec	9.2.1.10
230	UO	Monitor message	3 Sec	9.2.1.10
232	UP	Monitor message	3 Sec	9.2.1.10
234	CR	(AC) Plan an EO rig of Contact 1	5 Sec	N/A
236	CR	(NASO 1) Maintain radar plot of Contact 1 and the VTUAV	Cont.	N/A

Task OSD No.	Operator	Task	Completion Time	Top Down HGA Cross-Reference No.
270	CR	(NASO 1) Study Contact 1 using the CP140 EO suite	30 Sec	N/A
272	CR	(NASO 1) Advise Contact 1 not terrorist (no UAV container)	5 Sec	N/A
273	TN	Receive Message	5 Sec	9.2.2.3
275	UP	Monitor message	5 Sec	9.2.2.3
277	UO	Monitor message	5 Sec	9.2.2.3
312	CR	(AC) Contact 1 has been identified (the Guppy)	5 Sec	N/A
314	TN	Receive message	5 Sec	9.2.1.4
316	UO	Monitor message	5 Sec	9.2.1.4
318	UP	Monitor message	5 Sec	9.2.1.4
		--- 296 ... investigation of Contact 2 ---		
284	UP	Turn VTUAV to track towards the intercept point	10 Sec	7.1.2.1
286	UP	Maintain VTUAV track towards the intercept point	Cont.	7.1.3
296	UO	Request turn towards fishing boat	6 Sec	7.1.2.1
298	TN	Receive request	5 Sec	9.1.1
302	UP	Monitor request	5 Sec	9.2.1.6
356	UO	Observe fishing boat using VTUAV EO suite	15 Sec	7.1.5.2
358	UO	Observe that fishing boat is neutral	5 Sec	4.4.5
360	UO	Update surface plot with data on observed contact	8 Sec	2.1.4
362	UO	Advise crew of contact observed using VTUAV EO suite	5 Sec	9.4.1.3
364	TN	Receive message	5 Sec	9.2.1.10
366	UP	Receive message	5 Sec	9.2.1.10

Task OSD No.	Operator	Task	Completion Time	Top Down HGA Cross-Reference No.
368	CR	(Crew) Receive message	5 Sec	N/A
370	UP	Turn VTUAV to track towards the waypoint	10 Sec	7.1.2.1
372	UP	Maintain VTUAV track towards the waypoint	Cont.	7.1.3
		--- 294 ... updated surface plot is requested ---		
294	TN	Determine alternatives to find Contact 2	20 Sec	6.10
304	TN	Request a new surface plot from the MALE UAV	5 Sec	9.3.2.2
306	CR	(NAVCOM) Receive request	5 Sec	N/A
308	UO	Monitor request	5 Sec	9.2.1.10
310	UP	Monitor request	5 Sec	9.2.1.10
322	CR	(NAVCOM) ROC advises surface plot in 8 minutes	5 Sec	N/A
324	TN	Receive message	5 Sec	9.2.1.10
326	UO	Monitor message	5 Sec	9.2.1.10
328	UP	Monitor message	5 Sec	9.2.1.10
		--- 374 ... Contact 2 located on the VTUAV radar ---		
374	UO	Re-establish GENTRACK of Contact 2	10 Sec	7.1.7.3
375	UO	Study radar plot	Cont.	4.2.5
380	UO	Determine that radar contact is actually 2 boats	15 Sec	4.2.5
		--- 376 ... VTUAV route initiated and flow ---		
376	UP	Turn VTUAV to investigate Contact 2	5 Sec	7.1.2.1
378	UP	Maintain VTUAV track towards the Contact 2	Cont.	7.1.3
382	UP	Plan optimal route to investigate 2 boats	15 Sec	7.1.1.2.1
384	UP	Manoeuvre VTUAV to investigate 2 boats	Cont.	7.1.2.1

Task OSD No.	Operator	Task	Completion Time	Top Down HGA Cross-Reference No.
		--- 274 CP140 is enroute to Contact 4 ---		
274	TN	Provide AC with waypoint for Contact 4 and request turn	5 Sec	8.7.1
276	CR	(CP140 Plt) Receive request	5 Sec	N/A
278	UO	Monitor request	5 Sec	8.7.1
280	UP	Monitor request	5 Sec	8.7.1
320	CR	(AC) Turn towards Contact 4	10 Sec	N/A
330	TN	Plan aircraft altitude to keep VTUAV within radar range	10 Sec	8.9.3
332	TN	Request flight crew change altitude to 4000 ft	7 Sec	8.7.2
334	CR	(AC) Receive request for alt. Change, provide Contact 4 ETA	7 Sec	N/A
336	UO	Monitor request and ETA	7 Sec	8.7.2
338	UP	Monitor request and ETA	7 Sec	8.7.2
432	CR	(AC) Report AC level off after climb (4000 ft)	5 Sec	N/A
433	TN	Receive report that AC level after a climb (4000 ft)	5 Sec	9.2.1.8
		--- 386 ... Contact 2 is identified using the VTUAV EO ---		
386	UO	Observe possible contacts using VTUAV EO suite	15 Sec	7.1.5.1
388	UO	Observe that one of the contacts is Contact 2	10 Sec	7.1.5.2
389	UO	Determine that Contact 2 is not the terrorist vessel	30 Sec	4.4.5
390	UO	Update surface plot with data on observed contacts	8 Sec	4.1.5
392	UO	Advise of identity of contact observed with EO (Dolphin)	10 Sec	9.4.1.3
394	TN	Receive message	10 Sec	9.2.1.10
396	UP	Receive message	10 Sec	9.2.1.10
398	CR	(Crew) Receive message	10 Sec	N/A

Task OSD No.	Operator	Task	Completion Time	Top Down HGA Cross-Reference No.
		--- 340 ... Mini UAV prepared for release over Contact 4 ---		
340	TN	Plan the use of mini UAV to identify Contact 4	15 Sec	7.3.1.2
342	UO	Prep Mini UAV (free fall to 1000 ft, then search)	10 Sec	9.3.1
343	TN	Set Mini UAV opening height to 1000 ft	7 Sec	7.3.1.12
344	CR	(ASO 1) Receive request	10 Sec	N/A
346	TN	Monitor request	10 Sec	9.2.1.10
348	UP	Monitor request	10 Sec	9.2.1.10
		--- 400 ... the target of opportunity is investigated ---		
400	UP	Establish VTUAV in a circular pattern	Cont.	7.1.2.1
404	TN	Plan next waypoint for the VTUAV	15 Sec	7.1.1.3
429	UO	Monitor request	10 Sec	9.2.1.10
430	TN	Request VTUAV transit to view a target of opportunity	10 Sec	9.3.1
431	UP	Receive request to view target of opportunity	10 Sec	9.1.1
434	UP	Turn VTUAV to investigate a target of opportunity	5 Sec	7.1.2.1
436	UP	Maintain VTUAV track towards the target of opportunity	Cont.	7.1.3
438	UO	Observe target of opportunity using VTUAV EO suite	15 Sec	7.1.5.2
440	UO	Observe that the target of opportunity is not a terrorist	5 Sec	4.4.5
442	UO	Update surface plot with data on observed contact	8 Sec	2.1.4
444	UO	Advise of identity of target of opportunity	5 Sec	9.4.1.3
446	TN	Receive message	5 Sec	9.2.1.8
448	UP	Receive message	5 Sec	9.2.1.8
450	CR	(Crew) Receive message	5 Sec	N/A

Task OSD No.	Operator	Task	Completion Time	Top Down HGA Cross-Reference No.
		--- 416 ... surface plot updated using the CP140 radar ---		
416	CR	(NASO 1) Produce updated plot of the vessels near the CPF	15 Sec	N/A
418	CR	(NASO 1) Establish radar contact with the MH	15 Sec	N/A
420	CR	(NASO 1) Produce updated plot of the vessels near the VTUAV	15 Sec	N/A
422	CR	(NASO 1) Discuss updated surface plots	20 Sec	N/A
424	TN	Discuss updated surface plots	20 Sec	9.4.1.3
426	UO	Monitor discussion	20 Sec	9.2.1.10
428	UP	Monitor discussion	20 Sec	9.2.1.10
		--- 456 ... terrorist mission planning with the ROC ---		
456	TN	Conduct discussion about the possible location of terrorist	30 Sec	6.4.1
458	UO	Discuss possible location of terrorist	30 Sec	6.4.1
460	UP	Discuss possible location of terrorist	30 Sec	6.4.1
462	CR	(AC) Discuss possible location of terrorist	30 Sec	N/A
464	TN	Conclude that terrorist could have mixed with other boats	5 Sec	6.4.1
466	TN	Conclude that terrorist may have turned towards St. Johns	5 Sec	6.4.1
468	TN	Determine datum for new Contact 5	15 Sec	6.4.1
493	TN	Request an update from the ROC	10 Sec	9.3.1
495	CR	Receive request for an update from ROC	10 Sec	N/A
496	CR	ROC requests investigation of contact of 20 nm South of VTUAV 1, use caution	10 Sec	N/A
497	UP	Monitor request	20 Sec	9.2.3
498	TN	Receive request to investigate contact of interest, use caut.	20 Sec	9.1.3
499	UO	Monitor request	20 Sec	9.2.3

Task OSD No.	Operator	Task	Completion Time	Top Down HGA Cross-Reference No.
		--- 452 ... VTUAV tracking towards the waypoint ---		
452	UP	Turn VTUAV to re- establish track to TACNAV waypoint	10 Sec	7.1.2.1
454	UP	Maintain VTUAV track to TACNAV waypoint	Cont.	7.1.3
		--- 470 ... VTUAV route initiated and flow ---		
470	UP	Turn VTUAV towards new datum for Contact 5	10 Sec	7.1.2.1
474	UP	Maintain VTUAV track towards new datum for Contact 5	Cont.	7.1.3
		--- 486 ... VTUAV refuelling is planned ---		
486	UP	Recalculate VTUAV time on task	20 Sec	7.1.1.6.5
488	UP	Determine that VTUAV fuelling will conflict with MH recovery	10 Sec	7.1.1.6.6
490	UP	Report VTUAV time on task and conflicting refuelling time	5 Sec	9.4.1.4
492	TN	Receive report	5 Sec	9.2.1.8
494	UO	Receive report	5 Sec	9.2.1.8
126	CR	(ASO 1 & 2) Receive request		N/A

C.2.2 Bottom Up Goal Analysis (Part 2 of Scenario – Second 20 Minutes)

I want to perceive (that) (the) ...

Second Level Goals:

120 ... VTUAV 1 employment has been planned
134 ... CP140 is level at 4000 ft en route Contact 4
136 ... MALE UAV has been tasked to investigate Contact 3
170 ... UAV Op and Plt intend to investigate Boat 1
180 ... the MALE UAV will conduct ISAR imaging of Boat 3
194 ... VTUAV 1 is cautiously approaching Boat 1
206 ... plan for investigation of Contact 4 using a Mini UAV
260 ... CP140 on final run-in for deployment of MiniUAV1
292 ... VTUAV 1 has commenced EO Rig of Boat 1
330 ... MiniUAV1 is deployed
360 ... Boat 1 is classified
374 ... MALE UAV ISAR imagery of Boat 3 is analysed
410 ... the CP140 is turning south to Contact 5
416 ... Mini UAV is investigating Contact 4
428 ... Boat 1 is identified and determined to be neutral
447 ... investigation of Contact 4 by MiniUAV1 has commenced
475 ... plan for approaching Boat 2 is complete
500 ... identity Contact 4 is determined using Mini UAV1
535 ... illegal fishing activities of Contact 4 are reported
546 ... Boat 3 is classified using the ISAR imagery from MALE UAV
564 ... MALE UAV is tasked to conduct ISAR imaging of Contact 3
575 ... activity of known contacts in the area
600 ... message regarding the location of the operation area for VTUAV 2
606 ... Contact 3 is classified and determined to be neutral
630 ... MALE UAV is tasked to conduct ISAR imaging of Boat 2
640 ... VTUAV 1 is approaching Boat 2 and preparing for EO Rig of boat
660 ... wide search for possible terrorist vessel is initiated

Second and third level goals are listed below in the order that they appear in the network, not in the order listed above. Each line contains the OSD task number, a two-letter designator for the operator (TN=TACNAV; UO=UAV Operator; UP=UAV Pilot; CR=CP140 Crew; OU=Other Units), task description (OSD label), task completion time and corresponding top down goal number.

Task OSD No.	Operator	Task	Completion Time	Top Down HGA Cross-Reference No.
		--- 120 ... VTUAV 1 employment has been planned ---		
120	TN	Plan route for VTUAV 1 transit to Contact 5	6 Sec	7.1.1.1
122	TN	Verify that 4000 ft is adequate for control of VTUAV	12 Sec	7.1.9.1
124	TN	Monitor progress of CP140	3 Sec	8.9.3
126	UO	Produce VTUAV 1 radar surface plot about new datum	14 Sec	7.1.7.1
128	UP	Advise steady on a Southerly heading	3 Sec	9.4.1.4
130	UO	Receive message regarding VTUAV flight path	3 Sec	9.2.1.6
132	TN	Receive message regarding VTUAV flight path	3 Sec	9.2.1.6
164	TN	Receive radar plot data from the VTUAV 1	4 Sec	2.1.1
166	TN	Receive radar plot data from NASO1	6 Sec	2.1.1
168	TN	Fuse radar plot data and select 3 boats to investigate	16 Sec	2.5.2.1
		--- 134 ... CP140 is level at 4000 ft en route Contact 4 ---		
134	CR	(AC) Maintain CP140 in level flight at 4000 ft to Contact 4	Cont.	N/A
		--- 136 ... MALE UAV has been tasked to investigate Contact 3 ---		
136	CR	(TACNAV) MALE UAV standing by at Eastern boundary to assist	8 Sec	N/A
138	OU	(ROC) Advise MALE UAV standing by at Eastern boundary	8 Sec	N/A
140	CR	(TACNAV) Advise that MALE UAV able to assist	6 Sec	N/A
142	TN	Receive message that MALE UAV able to assist	6 Sec	9.2.4
144	UP	Monitor message that MALE UAV able to assist	6 Sec	9.2.4
146	UO	Monitor message that MALE UAV able to assist	6 Sec	9.2.4
147	TN	Develop a plan for the use of the MALE UAV	12 Sec	7.2.1
148	TN	Request that MALE UAV probe Contact 3, 7000 ft and above	8 Sec	9.3.1

Task OSD No.	Operator	Task	Completion Time	Top Down HGA Cross-Reference No.
150	CR	(NAVCOM) Receive request for MALE UAV tasking	8 Sec	N/A
152	UO	Monitor request for MALE UAV tasking	8 Sec	9.2.1.7
154	UP	Monitor request for MALE UAV tasking	8 Sec	9.2.1.7
156	CR	(NAVCOM) Request MALE UAV investigate Contact 3	16 Sec	N/A
157	OU	(ROC) Receive request MALE UAV investigate Contact 3	16 Sec	N/A
158	TN	Monitor request that MALE UAV investigate Contact 3	16 Sec	9.2.1.7
160	UO	Monitor request that MALE UAV investigate Contact 3	16 Sec	9.2.1.7
162	UP	Monitor request that MALE UAV investigate Contact 3	16 Sec	9.2.1.7
		--- 170 ... UAV Op and Plt intend to investigate Boat 1 ---		
170	TN	Direct UAV Op & Plt to investigate closest boat (Boat1)	5 Sec	9.3.1
172	UO	Receive direction	5 Sec	9.1.1
174	UP	Receive direction	5 Sec	9.1.1
176	UP	Plan route to approach Boat 1 from the East	8 Sec	7.1.1.1
178	UO	Configure EO suite for investigation	14 Sec	7.1.4.1
		--- 180 ... the MALE UAV will conduct ISAR imaging of Boat 3 ---		
180	TN	Request that MALE UAV use ISAR to image furthest boat (3)	12 Sec	9.3.1
182	CR	(NAVCOM) Receive request	12 Sec	N/A
184	CR	(NAVCOM) Request MALE UAV use ISAR to classify Boat 3	24 Sec	N/A
186	OU	(ROC) Receive request MALE UAV use ISAR to classify Boat 3	24 Sec	N/A
188	TN	Monitor request that MALE UAV use ISAR to classify Boat 3	24 Sec	9.2.1.7
190	UO	Monitor request that MALE UAV use ISAR to classify Boat 3	24 Sec	9.2.1.7
192	UP	Monitor request that MALE UAV use ISAR to classify Boat 3	24 Sec	9.2.1.7

Task OSD No.	Operator	Task	Completion Time	Top Down HGA Cross-Reference No.
318	OU	(ROC)Advise that ISAR imagery of Boat 3 available in 2 min.	10 Sec	N/A
320	CR	(NAVCOM)Receive message that ISAR imagery available 2 min.	10 Sec	N/A
324	TN	Monitor message that ISAR imagery available in 2 min.	10 Sec	9.2.4
326	UO	Monitor message that ISAR imagery available in 2 min.	10 Sec	9.2.4
328	UP	Monitor message that ISAR imagery available in 2 min.	10 Sec	9.2.4
		--- 194 ... VTUAV 1 is cautiously approaching Boat 1 ---		
194	UP	Insert waypoints to define VTUAV 1 route	3 Sec	7.1.1.3
196	UP	Control VTUAV 1 to maintain track while approaching Boat 1	10 Sec	7.1.2.1
198	UO	Conduct EO search in the direction of contact	15 Sec	7.1.5.1
200	UO	Initiate GENTRACK of Boat 1	4 Sec	7.1.7.3
202	TN	Monitor progress of VTUAV 1	15 Sec	7.1.3
203	UO	Receive request to investigate Boat 2 after 1	6 Sec	9.1.1
204	TN	Request that UAV Op and Plt investigate Boat 2 after 1	6 Sec	9.3.1
205	UP	Receive request to investigate Boat 2 after 1	6 Sec	9.1.1
212	UP	Plan stealthy approach to Boat 1 from the East	14 Sec	7.1.1.1
214	UP	Plot approach route	12 Sec	7.1.1.10
216	UP	Discuss approach route with the UAV Op	8 Sec	9.4.1.4
218	UO	Discuss approach route with the UAV Plt	8 Sec	9.4.1.4
220	TN	Monitor discussion	8 Sec	9.2.1.7
232	UP	Monitor VTUAV 1 progress towards Boat 1 turning point	10 Sec	7.1.3
234	TN	Study contact history of boats in the vicinity of Contact 5	15 Sec	2.5.2.1
236	UP	Discuss climbing VTUAV 1 as high as possible	6 Sec	9.4.1.4

Task OSD No.	Operator	Task	Completion Time	Top Down HGA Cross-Reference No.
238	UO	Discuss climbing VTUAV 1 as high as possible	6 Sec	9.4.1.4
240	UP	Initiate a climb to a height ASL just below cloud	5 Sec	7.1.2.2
242	UP	Maintain climb	13 Sec	7.1.3
244	UO	Advise approach base of cloud	3 Sec	9.4.1.4
246	UP	Receive warning of base of cloud	3 Sec	9.2.1.6
248	UP	Level off from climb, visually confirm clear of cloud	6 Sec	7.1.2.2
250	UP	Discuss suitability of height ASL for observation of Boat 1	8 Sec	9.4.1.4
252	UO	Discuss suitability of height ASL for observation of Boat 1	8 Sec	9.4.1.4
254	TN	Monitor discussion of height of VTUAV 1	8 Sec	9.2.1.7
256	UP	Monitor VTUAV 1 systems and fuel flow	Cont.	7.1.9.4
258	UO	Monitor GENTRACK of Boat 1	4 Sec	7.1.7.3
264	UP	Turn VTUAV 1 towards South to maintain route	14 Sec	7.1.2.1
266	UO	Commence EO Search for Boat 1	7 Sec	7.1.5.1
268	TN	Advise that one boat in the vicinity is the "Trust Me"	5 Sec	9.4.1.3
270	UO	Receive advice	5 Sec	9.2.1.8
272	UP	Receive advice	5 Sec	9.2.1.8
		--- 206 ... plan for investigation of Contact 4 using a Mini UAV ---		
206	TN	Plan investigation of Contact 4	10 Sec	7.3.1.2
208	CR	(NASO 1) Establish GENTRACK of Contact 4	6 Sec	N/A
210	CR	(NASO 1) Direct CP140 pilot for homing down Contact 4 MLA	15 Sec	N/A
222	TN	Update location of Contact 3	6 Sec	2.5.2.1
224	TN	Preset waypoints and default search pattern for Mini UAV 1	7 Sec	7.3.1.3

Task OSD No.	Operator	Task	Completion Time	Top Down HGA Cross-Reference No.
226	TN	Advise UAV Op of plan for Mini UAV investigation of Contact 4	12 Sec	9.4.1.4
228	UO	Respond to plan for Mini UAV investigation of Contact 4	12 Sec	9.4.1.4
230	UP	Monitor discussion regarding investigation of Contact 4	12 Sec	9.2.1.7
		--- 260 ... CP140 on final run-in for deployment of Mini UAV1 ---		
260	UP	Study the tactical situation regarding Contact 4	10 Sec	7.3.1.2
262	UO	Study the tactical situation regarding Contact 4	10 Sec	7.3.1.2
274	CR	(AC) Advise that CP140 is 2 minutes back from Contact 4	3 Sec	N/A
276	TN	Receive advice	3 Sec	9.2.1.8
278	UP	Receive advice	3 Sec	9.2.1.8
280	UO	Receive advice	3 Sec	9.2.1.8
282	TN	Note CP140 is turning towards Contact 4	4 Sec	8.9.4
284	CR	(AC)Advise CP140 reducing IAS for deployment of Mini UAV	6 Sec	N/A
286	TN	Receive message CP140 reducing IAS for deployment of Mini UAV	6 Sec	9.2.1.8
288	TN	Produce final determination of Pickle Point	10 Sec	7.3.1.3
290	TN	Update TACPLOT with new Pickle Point	5 Sec	7.3.1.3
		--- 292 ... VTUAV 1 has commenced EO Rig of Boat 1 ---		
292	UP	Turn VTUAV 1 towards WNW and start EO Rig of Boat 1	15 Sec	7.1.2.1
294	UO	Find intermittent EO image at location of radar contact	4 Sec	7.1.5.1
296	UP	Advise UAV Op that Rig of Boat 1 has commenced	3 Sec	9.4.1.3
298	UO	Receive message regarding EO Rig of Boat 1	3 Sec	9.2.1.7
300	TN	Monitor message regarding EO Rig of Boat 1	3 Sec	9.2.1.7
302	CR	(AC)Monitor message regarding EO Rig of Boat 1	3 Sec	N/A

Task OSD No.	Operator	Task	Completion Time	Top Down HGA Cross-Reference No.
304	UO	Verify that intermittent contact is a fishing boat	8 Sec	7.1.5.2
306	UO	Conduct classification and identification of Boat 1	Cont.	7.1.5.2
308	UO	Advise EO contact with Boat 1 has been established	4 Sec	9.4.1.3
310	TN	Receive message that EO contact has been established	4 Sec	9.2.1.7
312	UP	Receive message that EO contact has been established	4 Sec	9.2.1.7
314	UP	Turn VTUAV 1 to circle Boat 1	10 Sec	7.1.2.1
316	UP	Maintain circular route around Boat 1	Cont.	7.1.3
		--- 330 ... Mini UAV1 is deployed ---		
330	CR	(AC)Review online checklist for Mini UAV deployment	12 Sec	N/A
332	CR	(AC)Observe that the Mini UAV released at Pickle Point	3 Sec	N/A
334	CR	(AC)Advise crew that Mini UAV released over Contact 4	5 Sec	N/A
336	UO	Receive Message that Mini UAV released over Contact 4	5 Sec	9.2.1.7
338	TN	Receive Message that Mini UAV released over Contact 4	5 Sec	9.2.1.7
340	UP	Receive Message that Mini UAV released over Contact 4	5 Sec	9.2.1.7
342	UO	Request that UAV Plt advise when Mini UAV1 image is steady	4 Sec	9.3.1
344	UP	Roger request	4 Sec	9.1.1
346	TN	Observe that Mini UAV1 symbol has appeared on surface plot	2 Sec	7.3.3.1
348	UP	Observe that Mini UAV1 symbol has appeared on surface plot	2 Sec	7.3.3.1
350	UP	Track descent of Mini UAV1	5 Sec	7.3.3.2
352	UP	Monitor Mini UAV1 establishes level flight at 1000 ft	6 Sec	7.3.3.4

Task OSD No.	Operator	Task	Completion Time	Top Down HGA Cross-Reference No.
354	UP	Note location of Mini UAV1 wrt Contact 4 and plan approach	5 Sec	7.3.1.2
356	UP	Take control of Mini UAV1 and turn towards Contact 4	8 Sec	7.3.2.1
358	UP	Initiate BIT of Mini UAV1 systems and video	4 Sec	7.3.7.2
		--- 360 ... Boat 1 is classified ---		
360	UO	Record a series of high definition images of Boat 1	10 Sec	7.3.5.7
362	UO	Compare images of Boat 1 with known boat types	14 Sec	4.4.7
364	UO	Classify Boat 1 as a type similar to the terrorist boat	12 Sec	4.4.8
366	UO	Report classification of Boat 1	8 Sec	9.4.1.3
368	TN	Monitor report	8 Sec	9.2.1.7
370	UP	Receive classification report	8 Sec	9.2.1.8
372	UP	Check VTUAV 1 systems in case Boat 1 is terrorist boat	6 Sec	7.1.9.4
		--- 374 ... MALE UAV ISAR imagery of Boat 3 is analysed ---		
374	OU	(ROC) Advise that ISAR imagery of Boat 3 available on website	12 Sec	N/A
376	CR	(NAVCOM) Receives message	12 Sec	N/A
378	TN	Monitors message	12 Sec	9.2.4
380	TN	Request NASO1 download ISAR imagery, analyse and report	6 Sec	9.3.1
382	CR	(NASO1) Receive request	6 Sec	N/A
384	CR	(NASO1) Download/extract ISAR imagery from ROC image server	18 Sec	N/A
386	CR	(NASO1) Analyse imagery and determine that image is Boat 1	15 Sec	N/A
388	CR	(NASO1) Discuss analysis of ISAR imagery with UAV Op	12 Sec	N/A
390	UO	Discuss analysis of ISAR imagery with NASO1	12 Sec	9.4.1.3
392	TN	Monitor discussion	12 Sec	9.2.1.7

Task OSD No.	Operator	Task	Completion Time	Top Down HGA Cross-Reference No.
394	CR	(NASO1) Advise that MALE UAV & VTUAV 1 investigated same boat	4 Sec	N/A
396	TN	Receive message regarding mixup in tasking	4 Sec	9.2.1.8
398	TN	Request that MALE UAV conduct ISAR imaging of Boat 3	5 Sec	9.3.1
400	CR	(NAVCOM) Receive ROC tasking	5 Sec	N/A
402	UO	Monitor tasking that MALE UAV conduct ISAR imaging Boat 3	5 Sec	9.2.1.7
404	UP	Monitor tasking that MALE UAV conduct ISAR imaging Boat 3	5 Sec	9.2.1.7
406	CR	(NAVCOM) Request that MALE UAV conduct ISAR imaging of Boat 3	14 Sec	N/A
408	OU	(ROC) Receive request to conduct ISAR imaging of Boat 3	14 Sec	N/A
467	OU	(ROC) Advise that ISAR imagery of Boat 3 available in 2 min.	4 Sec	N/A
468	CR	(NAVCOM) Receive message that ISAR imagery available 2 min.	4 Sec	N/A
469	TN	Monitor message that ISAR imagery available 2 min.	4 Sec	9.4.1.3
470	UO	Monitor message that ISAR imagery available 2 min.	4 Sec	9.2.1.6
471	UP	Monitor message that ISAR imagery available 2 min.	4 Sec	9.2.1.6
		--- 410 ... the CP140 is turning south to Contact 5 ---		
410	TN	Request that AC turn to South and proceed to Contact 5	8 Sec	9.3.1
411	UO	Monitor request that AC turn to South and proceed Contact 5	8 Sec	9.2.1.6
412	UP	Monitor request that AC turn to South and proceed Contact 5	8 Sec	9.2.1.6
414	CR	(AC)Receive direction and advise turning to Contact 5	8 Sec	N/A
415	CR	(AC)Initiate turn and track towards Contact 5 (4000 ft)	25 Sec	N/A
		--- 416 ... Mini UAV is investigating Contact 4 ---		
416	UP	Advise UAV Op that Mini UAV1 is operational	4 Sec	9.4.1.4
417	UO	Receive message that Mini UAV1 ready for recce of Contact 4	4 Sec	9.2.1.7

Task OSD No.	Operator	Task	Completion Time	Top Down HGA Cross-Reference No.
418	UP	Discuss Mini UAV1 position wrt Contact 4 and request heading	8 Sec	9.4.1.3
419	CR	(NASO1)Provide UAV Plt with magnetic track to Contact 4	8 Sec	N/A
420	TN	Monitor discussion about Mini UAV1 position wrt Contact 4	8 Sec	9.2.1.7
421	UO	Monitor discussion about Mini UAV1 position wrt Contact 4	8 Sec	9.2.1.7
422	UP	Turn Mini UAV1 to track towards Contact 4	6 Sec	7.3.2.1
424	UP	Initiate Mini UAV1 descent to 300 ft	6 Sec	7.3.2.4
425	UP	Maintain Descent to 300 ft	22 Sec	7.3.2.2
426	UP	Level Mini UAV1 at 300 ft and continue tracking to Contact 4	5 Sec	7.3.3.4
		--- 428 ... Boat 1 is identified and determined to be neutral ---		
428	UO	Abeam Boat 1, zoom in on boat Registration No and Name	7 Sec	7.1.5.4
430	UO	Record high definition images of Registration No and Name	15 Sec	7.1.5.5
431	UO	Record images of boat structure	12 Sec	7.1.5.5
432	UO	Study bow midships and bow structure for lethal UAV	18 Sec	7.1.5.2
434	UP	Monitor images of Boat 1 recorded by UAV Op	25 Sec	7.1.5.6
436	UO	Discuss identification of Boat 1	6 Sec	9.4.1.3
437	TN	Monitor discussion about identification of Boat 1	6 Sec	9.2.1.7
438	UP	Discuss identification of Boat 1	6 Sec	9.4.1.3
440	UO	Conclude that Boat 1 is the "Trust Me" and not terrorist	5 Sec	4.3.3
442	UO	Advise crew that Boat 1 is not the terrorist	8 Sec	9.4.1.3
443	TN	Receive message that Boat 1 is not the terrorist	8 Sec	9.2.1.8
444	UP	Receive message that Boat 1 is not the terrorist	8 Sec	9.2.1.8
445	CR	(AC) Receive message that Boat 1 is not the terrorist	8 Sec	N/A

Task OSD No.	Operator	Task	Completion Time	Top Down HGA Cross-Reference No.
		--- 447 ... investigation of Contact 4 by Mini UAV1 has commenced ---		
447	CR	(NASO1) Advise UAV Op and Plt that Mini UAV1 is 2 nm back	4 Sec	N/A
448	UO	Receive message that Mini UAV1 is 2 nm back	4 Sec	9.2.1.8
449	TN	Monitor message that Mini UAV1 is 2 nm back	4 Sec	9.2.1.7
450	UP	Receive message that Mini UAV1 is 2 nm back	4 Sec	9.2.1.7
452	UO	Studies Mini UAV1 video and determines it is serviceable	9 Sec	7.3.7.3
454	UO	Advises that there is no EO image of a fishing boat	3 Sec	9.4.1.3
455	UP	Receive message that there is no EO image of a fishing boat	3 Sec	9.2.1.8
456	TN	Monitor message that there is no EO image of a fishing boat	3 Sec	9.2.1.7
458	UP	Passes control of Mini UAV1 to UAV Op for EO investigation	5 Sec	7.3.7.4
460	UP	Monitor Mini UAV1 systems	Cont.	7.3.7.3
462	UO	Establish translating waypoint at location of Contact 4	7 Sec	7.3.1.3
464	UO	Drag Mini UAV1 FOV trapezoid over Contact 4 and zoom	5 Sec	7.3.5.8
466	UO	Initiate automatic over-flight function and start recording	10 Sec	7.3.2.5
		--- 475 ... plan for approaching Boat 2 is complete ---		
475	UP	Determine location of Boat 2	8 Sec	7.1.1.2.7
476	UP	Verify with TACNAV that Boat 2 is next boat to investigate	5 Sec	9.4.1.4
477	TN	Confirm that Boat 2 is next boat for VTUAV to investigate	5 Sec	9.4.1.4
478	UO	Monitor discussion that Boat 2 is next boat to investigate	5 Sec	9.2.1.7
480	UO	Electronically stow data on Boat 1 and prepare for Boat 2	10 Sec	7.1.5.7
481	UO	Note that Boat 2 is tracking NNE	3 Sec	7.1.1.2.8
482	UP	Plan approach to Boat 2 from East like approach to Boat 1	7 Sec	7.1.1.2.1

Task OSD No.	Operator	Task	Completion Time	Top Down HGA Cross-Reference No.
483	UP	Plot approach route	12 Sec	7.1.1.10
484	UP	Insert waypoints to define VTUAV 1 route	8 Sec	7.1.1.3
485	UP	Control VTUAV 1 to maintain track while approaching Boat 2	Cont.	7.1.2.1
486	UO	Configure EO suite for investigation	7 Sec	7.1.4.1
487	UP	Request GENTRACK of Boat 2 and discuss anticipated approach	14 Sec	9.4.1.4
488	TN	Monitor discussion	14 Sec	9.2.1.7
490	UO	Advise GENTRACK initiated and discuss anticipated approach	14 Sec	9.4.1.4
491	UO	Conduct limited EO search in the direction of Boat 2	Cont.	7.1.5.1
492	TN	Monitor progress of VTUAV 1	10 Sec	7.1.3
		--- 500 ... identity Contact 4 is determined using Mini UAV1 ---		
500	UO	Conduct classification and ID of Contact 4	Cont.	4.4.5
502	UO	Advise EO contact with boat has been established	4 Sec	9.4.1.3
503	TN	Receive message EO contact with boat has been established	4 Sec	9.2.1.7
504	UP	Receive message EO contact with boat has been established	4 Sec	9.2.1.7
505	UP	Establish a cloverleaf pattern centered on Contact 4	10 Sec	7.3.1.8
506	UP	On over-flight of Cont. 4 set Mini UAV1 to execute pattern	6 Sec	7.3.2.5
508	UP	Monitor route of Mini UAV1 around Contact 4	Cont.	7.3.3.3
510	UO	Record a series of high definition images of Cont. 4	12 Sec	7.3.5.7
511	UO	Compare images of Contact 4 with known boat types	8 Sec	4.4.7
512	UO	Classify Contact 4 as a fishing boat	5 Sec	4.4.8
514	UO	Report classification of Contact 4	6 Sec	9.4.1.3
515	TN	Monitor report	6 Sec	9.2.1.7

Task OSD No.	Operator	Task	Completion Time	Top Down HGA Cross-Reference No.
516	UP	Receive classification report	6 Sec	9.2.1.10
518	UO	Abeam Contact 4, zoom in on Registration No and Name	12 Sec	7.3.5.4
519	UO	Record high definition images of Registration No and Name	15 Sec	7.3.5.7
520	UO	Record images of boat structure	8 Sec	7.3.5.7
521	UO	Study boat midships and bow structure for lethal UAV	10 Sec	7.3.5.2
522	UP	Monitor images of Contact 4 recorded by UAV Op	25 Sec	7.3.5.2
523	UO	Identify Contact 4 using the ROC database	14 Sec	4.4.5
524	UO	Discuss identification of Contact 4	8 Sec	9.4.1.3
525	TN	Monitor discussion	8 Sec	9.2.1.7
527	UP	Discuss identification of Contact 4	8 Sec	9.4.1.3
528	UO	Conclude that Contact 4 is the "Catch Me if You Can"	5 Sec	4.4.5
530	UO	Advise crew that Contact 4 is not the terrorist	6 Sec	9.4.1.3
531	TN	Receive message that Contact 4 is not the terrorist	6 Sec	9.2.1.10
532	UP	Receive message that Contact 4 is not the terrorist	6 Sec	9.2.1.10
533	CR	(AC) Receive message that Contact 4 is not the terrorist 6 Sec		N/A
		--- 535 ... illegal fishing activities of Contact 4 are reported ---		
535	UO	Determine that boat is fishing illegally in the zone	14 Sec	4.4.9
536	UO	Advise crew of illegal fisher	8 Sec	9.4.1.3
537	TN	Receive message of illegal fisher	8 Sec	9.2.1.10
538	UP	Receive message of illegal fisher	8 Sec	9.2.1.10
539	CR	(AC) Receive message of illegal fisher	8 Sec	N/A
540	TN	Request that NAVCOM action online fishing violation report	6 Sec	9.3.1

Task OSD No.	Operator	Task	Completion Time	Top Down HGA Cross-Reference No.
541	UP	Monitors discussion	6 Sec	9.2.1.7
542	CR	(NAVCOM) Reports that request will be actioned immediately	6 Sec	N/A
543	UO	Monitors discussion	6 Sec	9.2.1.7
544	UO	Set Mini UAV1 to autonomous ops to record evidence	7 Sec	7.3.2.6
		--- 546 ... Boat 3 is classified using the ISAR imagery from MALE UAV ---		
546	OU	(ROC) Advise that new ISAR imagery of Boat 3 available	12 Sec	N/A
547	CR	(NAVCOM) Receives message	12 Sec	N/A
548	TN	Monitors message	12 Sec	9.2.4
550	TN	Request NASO1 download ISAR imagery, analyse and report	6 Sec	9.3.1
551	CR	(NASO1) Receive request	6 Sec	N/A
552	CR	(NASO1) Download/extract ISAR imagery from ROC image server	14 Sec	N/A
553	CR	(NASO1) Analyse imagery and determine that image is Boat 3	18 Sec	N/A
554	CR	(NASO1) Discuss analysis of ISAR imagery with UAV Op	7 Sec	N/A
555	UO	Discuss analysis of ISAR imagery with NASO1	7 Sec	9.4.1.3
556	TN	Monitor discussion	7 Sec	9.2.1.7
558	CR	(NASO1) Determine that Boat 3 is small with no containers	9 Sec	N/A
559	CR	(NASO1) Advise that Boat 3 is classified neutral, no threat	12 Sec	N/A
560	TN	Receive message and advise no further investigation req.	12 Sec	9.4.1.3
561	UO	Monitor message and concur with findings, neutral class.	12 Sec	9.4.1.3
562	UP	Monitor discussion	12 Sec	9.2.1.7

Task OSD No.	Operator	Task	Completion Time	Top Down HGA Cross-Reference No.
		--- 564 ... MALE UAV is tasked to conduct ISAR imaging of Contact 3 ---		
564	TN	Request that MALE UAV use ISAR to image Contact 3	8 Sec	9.3.1
565	CR	(NAVCOM) Receive request	8 Sec	N/A
566	CR	(NAVCOM) Request MALE UAV use ISAR to classify Contact 3	16 Sec	N/A
567	OU	(ROC) Receive request and advise imagery in 3 minutes	16 Sec	N/A
568	TN	Monitor request	16 Sec	9.2.1.7
569	UO	Monitor request	16 Sec	9.2.1.7
570	UP	Monitor request	16 Sec	9.2.1.7
		--- 575 ... activity of known contacts in the area ---		
575	TN	Request an update of Contact 3 & boats near Boat 3 (Cont. 5)	13 Sec	9.3.1
576	UO	Monitor request	13 Sec	9.2.1.7
577	UP	Monitor request	13 Sec	9.2.1.7
578	CR	(NASO1) Receive request for radar update	13 Sec	N/A
579	CR	(NASO1) Update Contact 3 and boats near Boat 3 (Cont. 5)	18 Sec	N/A
580	TN	Receive radar update of surface plot	4 Sec	8.1.1
582	TN	Note progress of CP140 to vicinity of Boat 3 (Contact 5)	3 Sec	8.9.6
584	TN	Note manoeuvring of Contact 4	12 Sec	2.5.2.1
586	TN	Review real-time video from Mini UAV1	10 Sec	7.3.5.2
588	TN	Review last 5 minutes of video data collected over Contact 4	20 Sec	7.3.8.1
589	TN	Note that illegal fishing was recorded for Contact 4	6 Sec	4.4.9
590	TN	Note that Contact 4 can be identified	4 Sec	4.4.10

Task OSD No.	Operator	Task	Completion Time	Top Down HGA Cross-Reference No.
591	TN	Note that fishers saw Mini UAV & covered fish with tarpaulin	10 Sec	7.3.5.2
592	TN	Note that Mini UAV1 following Contact 4 as it heads South	13 Sec	7.3.3.5
593	TN	Review NAVCOM's online fishing violation report	12 Sec	9.4.2
		--- 600 ... message regarding the location of the operation area for VTUAV 2 ---		
600	OU	(CPF) Advise VTUAV 2 operating 30 nm South of VTUAV 1	16 Sec	N/A
601	TN	Monitor message and record location on surface plot	16 Sec	9.2.2.3
602	CR	(NAVCOM) Receive message	16 Sec	N/A
		--- 606 ... Contact 3 is classified and determined to be neutral ---		
606	OU	(ROC) Advise that ISAR imagery of Contact 3 is available	12 Sec	N/A
607	CR	(NAVCOM) Receives message	12 Sec	N/A
608	TN	Monitors message	12 Sec	9.2.4
610	TN	Request NASO1 download ISAR imagery, analyse and report	6 Sec	4.4.6
611	CR	(NASO1) Receive request	6 Sec	N/A
612	CR	(NASO1) Download/extract ISAR imagery from ROC image server	14 Sec	N/A
614	CR	(NASO1) Analyse imagery and determine that image is fisher	8 Sec	N/A
616	CR	(NASO1) Discuss analysis of ISAR imagery with UAV Op	10 Sec	N/A
617	UO	Discuss analysis of ISAR imagery with NASO1	10 Sec	9.4.1.3
618	TN	Monitor discussion	10 Sec	9.2.1.7
620	CR	(NASO1) Determine that Cont. 3 is trawler with no containers	7 Sec	N/A
622	CR	(NASO1) Advise that Boat 3 is classified neutral, no threat	5 Sec	N/A

Task OSD No.	Operator	Task	Completion Time	Top Down HGA Cross-Reference No.
623	TN	Receive message and advise no further investigation req.	5 Sec	9.4.1.3
624	UO	Monitor message and concur with findings, neutral class.	5 Sec	9.4.1.3
625	UP	Monitor discussion	5 Sec	9.2.1.7
		--- 630 ... MALE UAV is tasked to conduct ISAR imaging of Boat 2 ---		
630	TN	Request that MALE UAV use ISAR to image Boat 2	12 Sec	9.3.1
631	CR	(NAVCOM) Receive request	12 Sec	N/A
632	CR	(NAVCOM) Request MALE UAV use ISAR to classify Boat 2	16 Sec	N/A
633	OU	(ROC) Receive request and advise imagery in 3 minutes	16 Sec	N/A
634	TN	Monitor request	16 Sec	9.2.1.7
635	UO	Monitor request	16 Sec	9.2.1.7
636	UP	Monitor request	16 Sec	9.2.1.7
		--- 640 ... VTUAV 1 is approaching Boat 2 and preparing for EO Rig of boat ---		
640	UP	Turn VTUAV 1 towards WNW and track towards Boat 2	15 Sec	7.1.2.1
642	UO	Search for EO return at location of radar contact	8 Sec	7.1.5.1
644	UP	Advise UAV Op that Rig of Boat 2 to commenced, 1 min	6 Sec	9.4.1.4
645	UO	Receive message regarding EO Rig of Boat 2	6 Sec	9.2.1.7
646	TN	Monitor message regarding EO Rig of Boat 2	6 Sec	9.2.1.7
647	CR	(AC) Monitor message regarding EO Rig of Boat 2	6 Sec	N/A
648	UO	Note intermittent EO contact with small boat 3 nm from contact	5 Sec	7.1.5.2
649	TN	Receive message direct UAV Op to image boat during fly by	5 Sec	9.2.1.7

Task OSD No.	Operator	Task	Completion Time	Top Down HGA Cross-Reference No.
650	UP	Receive message and discuss investigation of small boat	5 Sec	9.2.1.7
652	UP	Monitor approach to waypoint to commence Rig of Boat 2	14 Sec	7.1.3
654	UP	Note that no route change req. to investigate small boat	4 Sec	7.1.3
		--- 660 ... wide search for possible terrorist vessel is initiated ---		
660	TN	Study surface plot for update on the progress of VTUAV 1	8 Sec	7.1.3
662	TN	Plan to widen the search for terrorist vessels	15 Sec	6.4.4
664	TN	Commence resizing the area displayed on workstations	12 Sec	6.4.5

C.2.3 Bottom Up Goal Analysis (Part 3 of Scenario – Last 20 Minutes)

I want to perceive (that) (the) ...

Part 3-1 … plan for the next portion of the mission is developed

120 ... plan to utilize available assets is developed
130 ... CP140 is in level flight en route Boat 2
132 ... VTUAV 1 is approaching Boat 2
148 ... ISAR imagery of Boat 2 is analysed

Part 3-2 … immediate response to the lost of VTUAV 1

164 ... operational viability of VTUAV 1
180 ... SITREPs are being sent
192 ... decision is made that the CP140 should be the SAC
203 ... message from MOC regarding CF188 tasking
207 ... message from CPF regarding VTUAV 2 handover
220 ... Mini UAV1 is terminated
230 ... the crew is briefed on the response to the lost of VTUAV 1

Part 3-3 … Mini UAVs are deployed over terrorist boat

244 ... new ISAR imagery of Boat 2 is downloaded and studied
260 ... CP140 is approaching Boat 2
265 ... handover of VTUAV 2 is completed
278 ... Mini UAVs 2 to 5 are readied for launch
315 ... deployment of Mini UAVs 2 to 4
325 ... CP140 is approaching release point for Mini UAV 5
335 ... Mini UAVs 2 to 4 are serviceable
355 ... deployment of Mini UAV 5
366 ... CP140 is proceeding to holding waypoint

Part 3-4 … assessment of threat coordinated

368 ... message to direct CF188s to stand-by
375 ... activities on the deck on the boat which may allow classification of boat
385 ... Mini UAV 5 is employed over the downed VTUAV 1
410 ... classification of the terrorist vessel is completed
427 ... decision to attack the terrorist boat has been made

Part 3-5 …CR-188 attack on terrorist boat proceeding

438 ... CF188 attack has been authorized
444 ... CP140 crew have initiated activities to deploy Laser Mini UAV
456 ... MALE UAV will be kept clear of CF188s
460 ... CP140 response to possible Lethal UAV launch is planned
470 ... Laser UAV is deployed from CP140 over terrorist boat
490 ... Laser UAV is deployed from CP140 over terrorist boat
510 ... control of the Laser UAV is established
524 ... VTUAV 2 will remain clear of CF188 attack

Part 3-6 … CF188 attack is reassessed

490 ... launch of Lethal UAV noted and initial response completed
526 ... reassessment of the need to attack to terrorists is completed

Part 3-7 …CF188 attack is re-initiated

550 ... directing, authorizing and authenticating of the CF188 attack is completed
560 ... utilization of Mini UAV during CF188 attack is coordinated

Part 3-8 … search for the airborne Lethal UAV is undertaken

556 ... search for the Lethal UAV is discussed and search plan initiated
574 ... all UAVs are set to autonomous mode to allow CP140 to commence search

Second and third level goals are listed below in the order that they appear in the network, not in the order listed above. Each line contains the OSD task number, a two-letter designator for the operator (TN=TACNAV; UO=UAV Operator; UP=UAV Pilot; CR=CP140 Crew; OU=Other Units), task description (OSD label), task completion time and corresponding top down goal number.

Third Level Goals (listed below each second level goal):

Task OSD No.	Operator	Task	Completion Time	Top Down HGA Cross-Reference No.
		--- 120 ... plan to utilize available assets is developed ---		
120	TN	Develop contingence plans to expand or refine the search	30 Sec	6.8.1
122	TN	Plan the use of the MALE UAV	9 Sec	7.2.1
123	TN	Plan the use of the CP140	14 Sec	8.1.3
124	TN	Discuss the tactical situation with the AC	35 Sec	9.4.1.5
125	CR	(AC) Discuss the tactical situation with the TACNAV	35 Sec	N/A
126	UO	Monitor discussion regarding the tactical situation	35 Sec	9.2.1.10
127	UP	Monitor discussion regarding the tactical situation	35 Sec	9.2.1.10
		--- 130 ... CP140 is in level flight en route Boat 2 ---		
130	CR	(AC) Maintain flight en route Boat 2	Cont.	N/A
131	CR	(AC) Note weather in the area is scattered, visibility 5 nm	3 Sec	N/A
133	CR	(AC) Recommend climb to 15,000 because weather is clearing	4 Sec	N/A
136	TN	Receive recommendation to climb to 15,000 ft and concur	4 Sec	9.4.1.5
139	CR	(AC) Climb to 15,000 ft to avoid IR missiles	180 Sec	N/A
		--- 132 ... VTUAV 1 is approaching Boat 2 ---		
132	UP	Maintain VTUAV flight towards the "turn in" waypoint	Cont.	7.1.3
134	UP	Study the route to be flown to investigate Boat 2	6 Sec	7.1.1.1
135	UP	Conduct a systems check of the VTUAV systems	9 Sec	7.1.9.4
137	UP	At waypoint turn VTUAV 1 to track towards Boat 2	22 Sec	7.1.2.1
138	UP	Maintain track at 800 ft to wpt to start Rig of Boat 2	Cont.	7.1.3
140	UO	Optimize EO systems for the environmental conditions	6 Sec	7.1.4.1

Task OSD No.	Operator	Task	Completion Time	Top Down HGA Cross-Reference No.
142	UO	Note that the fishing boat at 3 miles back is visible	4 Sec	7.1.5.2
143	UO	Search for Contact 5	11 Sec	7.1.5.1
145	UO	Photo fishing boat and observe fishers pointing at VTUAV	Cont.	7.1.5.5
		--- 148 ... ISAR imagery of Boat 2 is analysed ---		
148	OU	(ROC) ISAR imagery available on secure web site	15 Sec	N/A
149	TN	Monitor transmission	15 Sec	9.2.4
150	CR	(NAVCOM) Receive message that ISAR imagery of Boat 2 ready	15 Sec	N/A
151	TN	Request that NASO1 download the ISAR image and report	6 Sec	4.4.6
152	UO	Monitor request	6 Sec	9.2.1.7
153	UP	Monitor request	6 Sec	9.2.1.7
154	CR	(NAVO1)Receive request to download ISAR images & report	6 Sec	N/A
155	OU	(ROC) Advise that the ISAR indicates structure on boat	8 Sec	N/A
156	CR	(NAVCOM) Receive message regarding structure on Boat 2	8 Sec	N/A
157	UO	Receive message regarding structure on Boat 2	8 Sec	9.2.1.7
158	TN	Receive message regarding structure on Boat 2	8 Sec	9.2.1.7
159	UP	Receive message regarding structure on Boat 2	8 Sec	9.2.1.7
160	CR	(NASO1) Download ISAR imagery of Boat 2	27 Sec	N/A
161	CR	(NASO1) Analyse ISAR imagery	14 Sec	N/A
176	UO	Monitor comments Boat 2 has extensive mods to bow	12 Sec	9.2.1.7
177	TN	Receive comment Boat 2 has mods to bow may be UAV	12 Sec	9.4.1.3
178	UP	Monitor comments Boat 2 has extensive mods to bow	12 Sec	9.2.1.7
179	CR	(NASO1) Boat 2 has extensive mods to bow may be UAV	12 Sec	N/A

Task OSD No.	Operator	Task	Completion Time	Top Down HGA Cross-Reference No.
		--- 164 ... operational viability of VTUAV 1 ---		
164	UO	Note that EO video image of fishers has frozen	2 Sec	7.1.9.6
165	UP	Note that flight data from VTUAV 1 is lost	2 Sec	7.1.9.6
166	UO	Note that data link with VTUAV 1 is down	3 Sec	7.1.9.6
167	UP	Request radar sweep of the vicinity of VTUAV 1	9 Sec	2.1.1
168	CR	(NASO1) Receive request for radar sweep	9 Sec	N/A
169	TN	Monitor request	9 Sec	9.2.1.7
170	UO	Monitor request	9 Sec	9.2.1.7
171	CR	(NASO1) Switch radar to Air-to- Air and search for 1 VTUAV	5 Sec	N/A
172	CR	(NASO1) Report no contact with VTUAV 1	3 Sec	N/A
173	UP	Receive no contact message	3 Sec	9.2.1.8
174	TN	Receive no contact message	3 Sec	9.2.1.8
175	UO	Receive no contact message	3 Sec	9.2.1.8
214	UO	View last EO images and discuss loss of VTUAV 1	20 Sec	9.4.1.4
215	TN	View last EO images and discuss loss of VTUAV 1	20 Sec	9.4.1.4
216	UP	View last EO images and discuss loss of VTUAV 1	20 Sec	9.4.1.4
218	TN	Conclude Boat 2 must be viewed immediately it may be neutral	6 Sec	5.3.8
		--- 180 ... SITREPs are being sent ---		
180	TN	Request SITREP sent and MALE UAV continue imaging Boat 2	4 Sec	9.3.1
181	CR	(NAVCOM) Receive request	4 Sec	N/A
182	R	(NAVCOM) Prepare SITREP	9 Sec	N/A
184	CR	(NAVCOM) Provide SITREP and request more images of Boat 2	10 Sec	N/A

Task OSD No.	Operator	Task	Completion Time	Top Down HGA Cross-Reference No.
185	TN	Monitor message	10 Sec	9.2.1.7
186	OU	(ROC) Receive message	10 Sec	N/A
187	CR	(NAVCOM) Provide SITREP to MOC	10 Sec	N/A
188	TN	Monitor message	10 Sec	9.2.1.7
189	OU	(MOC) Receive message	10 Sec	N/A
		--- 192 ... decision is made that the CP140 should be the SAC ---		
192	TN	Assess command and control situation	12 Sec	3.5.1
194	TN	Determine location of CPF and MH	5 Sec	3.1.1
196	TN	Determine that CP140 should be SAC	12 Sec	3.5.2
198	TN	Advise crew that the CP140 has assumed the role of SAC	3 Sec	9.4.1.5
199	UO	Receive message	3 Sec	9.2.1.8
200	UP	Receive message	3 Sec	9.2.1.8
201	CR	(CP140 Crew) Receive message	3 Sec	N/A
		--- 203 ... message from MOC regarding CF188 tasking ---		
203	OU	(MOC) CF188s have been tasked to close at maximum speed	11 Sec	N/A
204	TN	Receive message regarding CF188s	11 Sec	9.2.2.3
205	CR	(NAVCOM) Receive message regarding CF188s new freqs	11 Sec	N/A
206	CR	(NAVCOM) Sets radio for CF188 frequencies	4 Sec	N/A
		--- 207 ... message from CPF regarding VTUAV 2 handover ---		
207	OU	(CPF) Vectoring VTUAV 2 towards Boat 2, handover 1 Min	13 Sec	N/A
208	UO	Receive message regarding VTUAV 2, handover in 1 Min	13 Sec	9.2.2.2
209	TN	Receive message regarding VTUAV 2, handover in 1 Min	13 Sec	9.2.2.2

Task OSD No.	Operator	Task	Completion Time	Top Down HGA Cross-Reference No.
210	UP	Receive message regarding VTUAV 2, handover in 1 Min	13 Sec	9.2.2.2
211	CR	(NAVCOM) Receive message regarding VTUAV 2 & handover	13 Sec	N/A
		--- 220 ... Mini UAV1 is terminated ---		
220	TN	Terminate Mini UAV 1	4 Sec	9.3.1
221	UO	Receive Mini UAV 1 termination order	4 Sec	9.1.1
222	UP	Receive Mini UAV 1 termination order	4 Sec	9.1.1
223	UO	Electronically stow all Mini UAV 1 files	14 Sec	7.3.7.5
224	UP	Direct Mini UAV 1 to climb to 1000 ft and dive into the sea	6 Sec	7.3.2.8
		--- 230 ... the crew is briefed on the response to the lost of VTUAV 1 ---		
230	TN	Request speed increase to VNE, home Boat 2 at 4000 ft	9 Sec	9.3.1
231	CR	(AC) Receive request to increase speed and home boat	9 Sec	N/A
232	TN	Advise all radio transmissions to be secure, full EW policies	5 Sec	9.3.4
233	CR	(NAVCOM) Receive direction full EW policies	5 Sec	N/A
235	TN	Plan investigation of Boat 2 using Mini UAVs	15 Sec	7.3.1.2
236	TN	Brief crew: over fly boat drop 3 Mini UAVs then orbit 4000 ft	18 Sec	7.3.1.10
237	UO	Receive briefing regarding release of 3 Mini UAVs	18 Sec	9.1.1
238	UP	Receive briefing regarding release of 3 Mini UAVs	18 Sec	9.1.1
239	CR	(Crew) Receive briefing about release of 3 Mini UAVs	18 Sec	N/A
240	TN	Request intentions be transmitted to Other Units	5 Sec	9.4.1.4
241	CR	(NAVCOM) Receive request to transmitted intentions	5 Sec	N/A

Task OSD No.	Operator	Task	Completion Time	Top Down HGA Cross-Reference No.
		--- 244 ... new ISAR imagery of Boat 2 is downloaded and studied ---		
244	OU	(ROC) New Boat 2 ISAR imagery available on secure web site	15 Sec	N/A
245	TN	Monitor transmission	15 Sec	9.2.1.7
246	CR	(NAVCOM) Receive message that ISAR imagery of Boat 2 ready	15 Sec	N/A
247	TN	Request that NASO1 download the new ISAR images and report	6 Sec	9.3.1
248	UO	Monitor request that NASO1 download ISAR images	6 Sec	9.2.1.7
249	UP	Monitor request that NASO1 download ISAR images	6 Sec	9.2.1.7
250	CR	(NASO1) Receive request to download ISAR images & report	6 Sec	N/A
251	CR	(NASO1) Download ISAR imagery of Boat 2	18 Sec	N/A
252	CR	(NASO1) Analyse ISAR imagery	8 Sec	N/A
253	CR	(NASO1) ISAR shows container shape on bow heading NNE	8 Sec	N/A
254	UO	Receive message regarding shape on Boat 2 and heading	8 Sec	9.2.1.7
255	TN	Receive message regarding shape on Boat 2 and heading	8 Sec	9.2.1.7
256	UP	Receive message regarding shape on Boat 2 and heading	8 Sec	9.2.1.7
		--- 260 ... CP140 is approaching Boat 2 ---		
260	CR	(AC) CP140 2 Min back from on top Boat 2	6 Sec	N/A
261	UO	CP140 2 Min back from on top Boat 2	6 Sec	9.2.1.8
262	TN	CP140 2 Min back from on top Boat 2	6 Sec	9.2.1.8
263	UP	CP140 2 Min back from on top Boat 2	6 Sec	9.2.1.8
305	CR	(AC) Advises CP140 slowing for release of Mini UAVs 2, 3 & 4	8 Sec	N/A
306	UO	Receive message regarding CP140 speed reduction	8 Sec	9.2.1.8

Task OSD No.	Operator	Task	Completion Time	Top Down HGA Cross-Reference No.
307	TN	Receive message regarding CP140 speed reduction	8 Sec	9.2.1.8
308	UP	Receive message regarding CP140 speed reduction	8 Sec	9.2.1.8
		--- 265 ... handover of VTUAV 2 is completed ---		
265	OU	(CPF) Handover of control of VTUAV 2, 8 min back	14 Sec	N/A
266	UO	Handover of control of VTUAV 2, 8 min back	14 Sec	9.1.2
267	TN	Handover of control of VTUAV 2, 8 min back	14 Sec	9.1.2
268	UP	Handover of control of VTUAV 2, 8 min back	14 Sec	9.1.2
269	CR	(NAVCOM) Accepts control of VTUAV 2	14 Sec	N/A
270	UO	Established data link with VTUAV 2 and checks EO system	12 Sec	7.1.9.2
271	UP	Established flight control of VTUAV 2 and checks all system	18 Sec	7.1.9.2
272	UP	Monitor VTUAV 2 on heading to the location of Boat 2	Cont.	7.1.3
273	UP	Advises that VTUAV 2 is serviceable and ready, 2500 ft	6 Sec	9.4.1.4
274	TN	Receive message regarding serviceability of VTUAV 2	6 Sec	9.2.1.6
275	UO	Receive message regarding serviceability of VTUAV 2	6 Sec	9.2.1.6
		--- 278 ... Mini UAVs 2 to 5 are readied for launch ---		
278	TN	Request that 3 Mini UAVs be made ready at 3 altitudes	25 Sec	9.3.1
279	UO	Receive request, will transmit all photos and video via net	25 Sec	9.1.1
280	UP	Receive request, alt 1000, 800 & 600 ft, cloverleaf patterns	25 Sec	9.1.1
281	CR	(Ordnance) Receive request to load Mini UAVs (No 2, 3 & 4)	25 Sec	N/A
290	UP	Recommend Mini UAV deployed over lost VTUAV 1	9 Sec	9.4.1.4
291	UO	Monitor recommendation that Mini UAV be deployed	9 Sec	9.2.1.7
292	TN	Receive suggestion, request over flight after Boat 2	9 Sec	9.2.1.8

Task OSD No.	Operator	Task	Completion Time	Top Down HGA Cross-Reference No.
293	CR	(AC) Receive request for over-flight of lost VTUAV 1	9 Sec	N/A
294	TN	Insert waypoint at site of lost contact with VTUAV 1	7 Sec	7.3.1.3
295	CR	(Ordnance) Will prepare a fourth Mini UAV (No 5)	5 Sec	N/A
296	UO	Receive message regarding fourth Mini UAV (No 5)	5 Sec	9.2.1.8
297	TN	Receive message regarding fourth Mini UAV (No 5)	5 Sec	9.2.1.8
298	UP	Advise will set search height of Mini UAV 5 to 600 ft	5 Sec	9.4.1.4
300	CR	(NASO1) Finds VTUAV 1 wreckage on radar and plots position	12 Sec	N/A
301	CR	(NASO1) Advises wreckage of VTUAV 1 found and plotted	6 Sec	N/A
302	TN	Receives message regarding location of VTUAV 1 wreckage	6 Sec	9.2.1.10
303	TN	Updates waypoint for release of Mini UAV 5	4 Sec	7.3.1.3
		--- 315 ... deployment of Mini UAVs 2 to 4 ---		
315	CR	(AC) Advise Mini UAVs 2, 3 & 4 released over Boat 2	15 Sec	N/A
316	UO	Receive message regarding deployment of Mini UAVs	15 Sec	9.2.1.6
317	TN	Receive message regarding deployment of Mini UAVs	15 Sec	9.2.1.6
318	UP	Receive message regarding deployment of Mini UAVs	15 Sec	9.2.1.6
319	TN	Note 3 Mini UAV symbols on Surface Plot (No 2, 3 & 4)	23 Sec	7.3.3.1
320	UO	Note 3 Mini UAV symbols on Surface Plot (No 2, 3 & 4)	23 Sec	7.3.3.1
321	UP	Note 3 Mini UAV symbols on Surface Plot (No 2, 3 & 4)	23 Sec	7.3.3.1
		--- 325 ... CP140 is approaching release point for Mini UAV 5 ---		
325	CR	(AC) Turn CP140 to waypoint for the release of Mini UAV 5	17 Sec	N/A
328	CR	(AC) Advise 1 min back from release of Mini UAV 5	4 Sec	N/A
329	UO	Receive message regarding deployment of Mini UAV 5	4 Sec	9.2.1.9

Task OSD No.	Operator	Task	Completion Time	Top Down HGA Cross-Reference No.
330	TN	Receive message regarding deployment of Mini UAV 5	4 Sec	9.2.1.9
331	UP	Receive message regarding deployment of Mini UAV 5	4 Sec	9.2.1.9
326	CR	(AC) Maintain level flight to waypoint at 15,000 ft	Cont.	N/A
		--- 335 ... Mini UAVs 2 to 4 are serviceable ---		
335	UP	Observe Mini UAV 2 providing flight data and take control	8 Sec	7.3.2.1
336	UP	Establish Mini UAV 2 in 800 ft circular pattern around Boat 2	5 Sec	7.3.2.7
337	UP	Observe Mini UAV 3 providing flight data and take control	8 Sec	7.3.2.1
338	UP	Establish Mini UAV 3 in 400 ft clover leaf around Boat 2	5 Sec	7.3.2.7
339	UP	Observe Mini UAV 4 providing flight data and take control	8 Sec	7.3.2.1
340	UP	Establish Mini UAV 4 in 200 ft clover leaf around Boat 2	5 Sec	7.3.2.7
342	UP	Monitor flight patterns of Mini UAVs 2, 3 & 4	Cont.	7.3.3.3
345	UO	Note EO video from Mini UAV 2 and optimize image	10 Sec	7.3.4.1
346	UO	Note EO video from Mini UAV 3 and optimize image	10 Sec	7.3.4.1
347	UO	Note EO video from Mini UAV 4 and optimize image	10 Sec	7.3.4.1
350	UO	Ready to take responsibility for Mini UAVs 2, 3 & 4	12 Sec	9.4.1.4
351	TN	Monitor discussion about control of Mini UAVs	12 Sec	9.2.1.7
352	UP	"You have control" of Mini UAVs 2, 3 & 4	12 Sec	9.1.1
		--- 355 ... deployment of Mini UAV 5 ---		
355	CR	(AC) Advise Mini UAV 5 released over VTUAV 1 datum	5 Sec	N/A
356	UO	Receive message regarding deployment of Mini UAV 5	5 Sec	9.2.1.9
357	TN	Receive message regarding deployment of Mini UAV 5	5 Sec	9.2.1.9
358	UP	Receive message regarding deployment of Mini UAV 5	5 Sec	9.2.1.9

Task OSD No.	Operator	Task	Completion Time	Top Down HGA Cross-Reference No.
360	TN	Provide a holding waypoint well clear of the threat	7 Sec	7.3.1.3
362	TN	Note Mini UAV 5 symbol on Surface Plot near datum	12 Sec	7.3.3.1
363	UO	Note Mini UAV 5 symbol on Surface Plot near datum	12 Sec	7.3.3.1
364	UP	Note Mini UAV 5 symbol on Surface Plot near datum	12 Sec	7.3.3.1
		--- 366 ... CP140 is proceeding to holding waypoint ---		
366	CR	(AC) Turn CP140 to waypoint	11 Sec	N/A
367	CR	(AC) Maintain level flight to waypoint at 15,000 ft	120 Sec	N/A
		--- 368 ... message to direct CF188s to stand-by ---		
368	OU	(Hornets) Advise 10 min back with precision guided weapons	10 Sec	N/A
369	TN	Receive message that Hornets are 10 minutes back with PGWs	10 Sec	9.2.2.3
370	CR	(NAVCOM) Receive message that Hornets are 10 minutes back	10 Sec	N/A
371	TN	Roger, stand by for visual confirmation of threat	6 Sec	9.1.1
372	OU	(Hornets) Receive stand by for visual confirmation of threat	6 Sec	N/A
373	CR	(NAVCOM) Monitor message stand by for visual confirm.	6 Sec	N/A
378	CR	(NAVCOM) Provide CF188s with a SITREP	15 Sec	N/A
379	OU	(Hornets) Receive SITREP	15 Sec	N/A
		--- 375 ... activities on the deck on the boat which may allow classification of boat ---		
375	UO	Study EO images from Mini UAVs observe Boat 2 heading NNE	20 Sec	7.3.5.6
376	TN	Study EO images from Mini UAVs observe Boat 2 heading NNE	20 Sec	7.3.5.6
377	UP	Study EO images from Mini UAVs observe Boat 2 heading NNE	20 Sec	7.3.5.6
380	UO	Observe men on deck and container installed on bow	12 Sec	7.3.5.2
381	TN	Observe men on deck and container installed on bow	12 Sec	7.3.5.2

Task OSD No.	Operator	Task	Completion Time	Top Down HGA Cross-Reference No.
382	UP	Observe men on deck and container installed on bow	12 Sec	7.3.5.2
395	UO	Discuss UAV Plt taking control of Mini UAV 4 and flying lower	6 Sec	9.4.1.4
396	TN	Discuss UAV Plt taking control of Mini UAV 4 and flying lower	6 Sec	9.4.1.4
397	UP	Discuss UAV Plt taking control of Mini UAV 4 and flying lower	6 Sec	9.4.1.4
399	UP	Take Manual Control of Mini UAV 4 to investigate container	4 Sec	7.3.2.9
400	UP	Conduct low pass over boat and manoeuvre about vessel to view	Cont.	7.3.2.10
402	UO	Observe JATO UAV mounted in a container, men removing covers	8 Sec	7.3.5.2
403	TN	Observe JATO UAV mounted in a container, men removing covers	8 Sec	7.3.5.2
404	UP	Observe JATO UAV mounted in a container, men removing covers	8 Sec	7.3.5.2
405	UO	Observe second container which may be second Lethal UAV	4 Sec	7.3.5.2
406	TN	Observe second container which may be second Lethal UAV	4 Sec	7.3.5.2
407	UP	Observe second container which may be second Lethal UAV	4 Sec	7.3.5.2
		--- 385 ... Mini UAV 5 is employed over the downed VTUAV 1 ---		
385	UP	Observe Mini UAV 5 providing flight data and take control	8 Sec	7.3.2.1
386	UP	Put Mini UAV 5 in 800 ft circ. pattern around downed VTUAV 1	5 Sec	7.3.2.7
387	UP	Monitor flight pattern of Mini UAV 5 around VTUAV 1	Cont.	7.3.3.3
388	UO	Note EO video from Mini UAV 5 and optimize image	10 Sec	7.3.4.1
389	UO	Ready to take responsibility for Mini UAV 5	12 Sec	9.4.1.4
390	TN	Monitor discussion about control of Mini UAV 5	12 Sec	9.2.1.7
391	UP	"You have control" of Mini UAV 5	12 Sec	9.1.1
392	UO	Verify Mini UAV 5 recording video of downed VTUAV 1	9 Sec	7.3.5.9

Task OSD No.	Operator	Task	Completion Time	Top Down HGA Cross-Reference No.
		--- 410 ... classification of the terrorist vessel is completed ---		
410	UO	Discuss finding of the Lethal UAV, conclude terrorist found	12 Sec	9.4.1.3
411	TN	Discuss finding of the Lethal UAV, conclude terrorist found	12 Sec	9.4.1.3
412	UP	Monitor discussion regarding finding the terrorist vessel	12 Sec	9.2.1.10
414	TN	Conclude Lethal UAV is being readied for launch	6 Sec	5.3.1
416	UO	View images & discuss actions of the personnel on vessel	15 Sec	9.4.1.3
417	TN	View images & discuss actions of the personnel on vessel	15 Sec	9.4.1.3
418	UP	View images & discuss actions of the personnel on vessel	15 Sec	9.4.1.3
420	TN	Plan response to situation-hit Lethal UAV with Mini UAV?	20 Sec	5.5.6
422	UO	Reqst that UAV Plt point Mini UAV 4 at mid ship container	6 Sec	9.3.1
423	UP	Receive request regarding manoeuvring Mini UAV 4	6 Sec	9.1.1
424	UP	Control Mini UAV 4 to give a good view of mid ship area	14 Sec	7.3.2.10
425	UO	Study image of 2nd container & conclude that it may be UAV	14 Sec	7.3.5.2
		--- 427 ... decision to attack the terrorist boat has been made ---		
427	UO	Advise that boat probably has 2nd Lethal UAV onboard	7 Sec	9.4.1.3
428	TN	Advise crew that intention is to destroy terrorist boat	7 Sec	9.4.1.5
429	UP	Receive intentions and advise ready to proceed	7 Sec	9.4.1.5
430	CR	(AC) Concur with decision to destroy terrorist boat	7 Sec	N/A
432	TN	Discuss chances of hitting Lethal UAV with Mini UAV 4	9 Sec	9.4.1.4
433	UP	Advise that control mechanism is not accurate enough	9 Sec	9.4.1.4
434	UO	Suggest laser designator Mini with CF188 Laser Guided Bomb	9 Sec	9.4.1.4
436	TN	Conclude that CF188 attack is best response to situation	5 Sec	5.5.2

Task OSD No.	Operator	Task	Completion Time	Top Down HGA Cross-Reference No.
		--- 438 ... CF188 attack has been authorized ---		
438	TN	Issue FLASH, dir, authorizing immediate attack by Hornets	14 Sec	9.3.2.3
439	OU	Hornets) Direction, authoriz. and authentication to attack	14 Sec	N/A
440	UO	Monitor FLASH message	14 Sec	9.2.1.7
441	UP	Monitor FLASH message	14 Sec	9.2.1.7
442	CR	(AC) Monitor FLASH message	14 Sec	N/A
		--- 444 ... CP140 crew have initiated activities to deploy Laser Mini UAV ---		
444	TN	Request over flight of Boat 2 at 15,000 to deploy Laser UAV	4 Sec	8.7.1
445	CR	(AC) Receive request and advise 2 min back (15,000 ft)	4 Sec	N/A
446	UO	Monitor request	4 Sec	9.2.1.7
447	UP	Monitor request	4 Sec	9.2.1.7
449	TN	Insert Laser UAV holding waypoint East of terrorist boat	3 Sec	7.3.1.3
452	TN	Request Laser UAV be deployed and established in hold patt.	8 Sec	7.3.1.11
453	UO	Monitor request to launch Laser UAV	8 Sec	9.2.1.7
454	UP	Receive request to establish Laser UAV in holding pattern	8 Sec	9.1.1
455	CR	(Ordnance) Receive request to prep Laser UAV for launch	8 Sec	N/A
		--- 456 ... MALE UAV will be kept clear of CF188s ---		
456	CR	(NAVCOM) Request that(ROC)keep MALE UAV in SW sector	15 Sec	N/A
457	TN	Monitor request regarding keeping MALE UAV clear	15 Sec	9.2.1.7
458	OU	(ROC) Receive request to keep MALE UAV clear of Fighters	15 Sec	N/A

Task OSD No.	Operator	Task	Completion Time	Top Down HGA Cross-Reference No.
		--- 460 ... CP140 response to possible Lethal UAV launch is planned ---		
460	TN	Advise Lethal UAV launch soon, track as long as possible	8 Sec	9.4.1.3
461	CR	(NASO1) Receive request to track Lethal UAV	8 Sec	N/A
462	CR	(NASO1) Switches to Air-to-Air mode	7 Sec	N/A
463	TN	Organize EO images to study terrorist activities on boat	Cont.	7.3.5.10
464	CR	(AC)Advise CP140 could trail Lethal UAV	9 Sec	N/A
465	UO	Note suggestion regarding CP140 trailing Lethal UAV	9 Sec	5.5.6
466	TN	Receive suggestion regarding CP140 trailing Lethal UAV	9 Sec	5.5.6
467	UP	Note suggestion regarding CP140 trailing Lethal UAV	9 Sec	5.5.6
		--- 470 ... Laser UAV is deployed from CP140 over terrorist boat ---		
470	CR	(AC)Advise CP140 1 min to drop point	3 Sec	N/A
471	UO	Note message that CP140 is 1 min back from UAV drop point	3 Sec	9.2.1.8
472	TN	Receive message that CP140 is 1 min back from UAV drop point	3 Sec	9.2.1.8
473	UP	Note message that CP140 is 1 min back from UAV drop point	3 Sec	9.2.1.8
475	CR	(AC)Advise Laser UAV released over terrorist boat	5 Sec	N/A
476	UO	Receive message regarding deployment of Laser UAV	5 Sec	9.2.1.6
477	TN	Receive message regarding deployment of Laser UAV	5 Sec	9.2.1.6
478	UP	Receive message regarding deployment of Laser UAV	5 Sec	9.2.1.6
479	TN	Provide a Laser UAV holding waypoint near threat vessel	7 Sec	7.3.1.3
480	TN	Provide a CP140 holding waypt well clear of the threat	7 Sec	8.3.2
481	TN	Provide a VTUAV2 holding waypoint SE of threat vessel	7 Sec	7.1.1.3
482	TN	Note Laser UAV symbol on Surface Plot near datum	8 Sec	7.3.3.1

Task OSD No.	Operator	Task	Completion Time	Top Down HGA Cross-Reference No.
483	UO	Note Laser UAV symbol on Surface Plot near datum	8 Sec	7.3.3.1
484	UP	Note Laser UAV symbol on Surface Plot near datum	8 Sec	7.3.3.1
486	CR	(AC) Turn CP140 to waypoint	11 Sec	N/A
487	CR	(AC)Maintain level flight to waypoint at 15,000 ft	120 Sec	N/A
		--- 490 ... launch of Lethal UAV noted and initial response completed ---		
490	UO	Note Lethal UAV launch from terrorist boat	3 Sec	5.2.1
491	TN	Note Lethal UAV launch from terrorist boat	3 Sec	5.2.1
492	UP	Note Lethal UAV launch from terrorist boat	3 Sec	5.2.1
494	UO	Alert crew that terrorists have launched the Lethal UAV	5 Sec	9.4.1.3
495	TN	Receive message, request NASO tracking and NAVCOM update MOC	5 Sec	9.2.1.8
496	UP	Receive message regarding launch of Laser UAV	5 Sec	9.2.1.6
497	CR	(NASO1) Receive message regarding tracking Lethal UAV	5 Sec	N/A
498	CR	(NASO1) Initiate tracking of Lethal UAV	8 Sec	N/A
499	CR	(NAVCOM) Prepare FLASH message	7 Sec	N/A
500	TN	Commit AD12 to engage launched Lethal UAV	8 Sec	5.5.6
501	OU	(AD12) Receive direction to engage launched Lethal UAV	8 Sec	N/A
502	CR	(NAVCOM) Transmit FLASH message of Lethal UAV launch	13 Sec	N/A
503	TN	Monitor message regarding Lethal UAV launch	13 Sec	9.2.1.7
504	OU	(MOC) Receive message regarding Lethal UAV launch	13 Sec	N/A
505	OU	Monitor AD12 direction to engage launched Lethal UAV	8 Sec	9.2.1.7
506	CR	(NASO1) Tell crew that Lethal UAV radar contact lost in turn	6 Sec	N/A
507	UO	Receive message regarding lost of Lethal UAV radar contact	6 Sec	9.2.1.6

Task OSD No.	Operator	Task	Completion Time	Top Down HGA Cross-Reference No.
508	TN	Receive message regarding lost of Lethal UAV radar contact	6 Sec	9.2.1.6
509	UP	Receive message regarding lost of Lethal UAV radar contact	6 Sec	9.2.1.6
		--- 510 ... control of the Laser UAV is established ---		
510	UP	Observe Laser Mini UAV flight data and take control	8 Sec	7.3.2.1
512	UP	Establish Laser Mini UAV in 800 ft flight to holding waypt	5 Sec	7.3.2.7
514	UP	Monitor flight path of Laser Mini UAV	Cont.	7.3.3.3
516	UO	Note EO video of Laser Mini UAV and optimize image	10 Sec	7.3.4.1
518	UP	Establish Laser Mini UAV in holding pattern	8 Sec	7.3.2.7
519	UP	Monitor Laser Mini UAV flight in holding pattern	Cont.	7.3.3.3
520	UO	Slave Laser Mini UAV to Contact 5 (Boat 2)	14 Sec	7.3.5.6
		--- 524 ... VTUAV 2 will remain clear of CF188 attack ---		
524	UP	Turn VTUAV2 towards holding waypoint SE of threat vessel	9 Sec	7.1.2.1
525	UP	Verify that VTUAV2 will be clear of CF188 intended track	5 Sec	7.1.1.1
527	UP	Monitor VTUAV 2 on heading to the holding point	Cont.	7.1.3
		--- 526 ... reassessment of the need to attack to terrorists is completed ---		
526	TN	Plan response to attack by terrorists, still use CF188s?	18 Sec	5.5.2
530	UO	Discuss capture of terrorists and chances of 2nd Lethal UAV	24 Sec	9.4.1.3
531	TN	Discuss capture of terrorists and chances of 2nd Lethal UAV	24 Sec	9.4.1.3
532	UP	Discuss capture of terrorists and chances of 2nd Lethal UAV	24 Sec	9.4.1.3
533	CR	(AC) Discuss capture of terrorists & 2nd Lethal UAV	24 Sec	N/A
541	TN	Decide to attack terrorists using CF188s (AD34)	5 Sec	5.5.6
542	TN	Direct Mini UAVs 3 & 4 to fly at possible 2nd UAV container	20 Sec	7.3.1.10

Task OSD No.	Operator	Task	Completion Time	Top Down HGA Cross-Reference No.
543	UO	Use Mini UAVs 3 & 4 video to view possible UAV container	20 Sec	9.1.1
544	UP	Monitor direction to use Mini UAVs 3 & 4	20 Sec	9.2.1.7
545	UO	Discuss video of terrorists preparing 2nd UAV for launch	7 Sec	9.4.1.3
546	TN	Discuss video of terrorists preparing 2nd UAV for launch	7 Sec	9.4.1.3
547	UP	Discuss video of terrorists preparing 2nd UAV for launch	7 Sec	9.4.1.3
		--- 550 ... directing, authorizing and authenticating of the CF188 attack is completed ---		
535	OU	(CF188s) Note 1 minute back from IP	2 Sec	N/A
536	OU	(CF188s) Ready to attack, one min from IP	9 Sec	N/A
537	UO	CF188s ready to attack, one min from IP	9 Sec	5.6.4
538	TN	CF188s ready to attack, 1 min, do not arm weapons (standby)	9 Sec	5.6.3
539	UP	CF188s ready to attack, one min from IP	9 Sec	5.6.4
540	CR	(AC) CF188s ready to attack, one min from IP	9 Sec	N/A
548	OU	(AD34) Receive direction to engage terrorist boat	6 Sec	N/A
549	UO	Monitor CF188 clearance to engage terrorist boat	6 Sec	9.2.1.10
550	TN	Commit AD34 to engage terrorist boat	6 Sec	5.6.3
551	UP	Monitor CF188 clearance to engage terrorist boat	6 Sec	9.2.1.10
552	CR	(AC) Monitor CF188 clearance to engage terrorist boat	6 Sec	N/A
553	UP	Command Mini UAVs to descend to 100 ft ASL to avoid CF188s	8 Sec	7.3.2.4
554	UP	Command VTUAV2 to approach and maintain a hover, anti col ON	5 Sec	7.1.2.5

Task OSD No.	Operator	Task	Completion Time	Top Down HGA Cross-Reference No.
		--- 560 ... utilization of Mini UAV during CF188 attack is coordinated ---		
555	UP	Plan route for Laser UAV for CF188 LGB attack	18 Sec	7.3.1.8
560	UO	Direct all UAVs to view target at CF188 time on target	20 Sec	7.3.5.2
561	TN	Direct UAVs to view and illum. target at CF188 time on tgt	20 Sec	7.3.1.10
562	UP	Direct Laser UAV to illuminate boat at CF188 time on target	20 Sec	9.1.1
564	UO	Observe CF188 attack, and destruction of terrorist boat	15 Sec	7.3.5.2
565	TN	Observe CF188 attack, and destruction of terrorist boat	15 Sec	7.3.5.2
566	UP	Observe CF188 attack, and destruction of terrorist boat	15 Sec	7.3.5.2
567	TN	Provide damage report to CF188s	8 Sec	5.7.8
568	OU	Receive damage report from CP140 TACNAV	8 Sec	N/A
		--- 556 ... search for the Lethal UAV is discussed and search plan initiated ---		
556	UO	Discuss CP140 search for the Lethal UAV heading to St Johns	24 Sec	9.4.1.5
557	TN	Discuss CP140 search for the Lethal UAV heading to St Johns	24 Sec	9.4.1.5
558	UP	Discuss CP140 search for the Lethal UAV heading to St Johns	24 Sec	9.4.1.5
559	CR	(AC) Discuss search for the Lethal UAV heading to St Johns	24 Sec	N/A
570	TN	Plan search for Lethal UAV using CF188, CP140 & MALE UAV	25 Sec	4.1.10
		--- 574 ... all UAVs are set to autonomous mode to allow CP140 to commence search ---		
572	UO	Set Mini UAVs to autonomous mode to view sinking boat	45 Sec	7.3.2.6
574	UP	Advise UAV Op that Mini UAVs on autonomous mode about datum	6 Sec	9.4.1.5
575	TN	Monitor message regarding Mini UAVs on autonomous mode	6 Sec	9.2.1.7
576	UO	Receive message regarding Mini UAVs on autonomous mode	6 Sec	9.2.1.6
578	UP	Plan route for VTUAV 2 to view boat, clear of Mini UAVs	30 Sec	7.1.1.1

Task OSD No.	Operator	Task	Completion Time	Top Down HGA Cross-Reference No.
579	UP	Initiate VTUAV 2 autonomous mode to follow planned route	4 Sec	7.1.2.4
580	UP	Advise UAV Op that VTUAV 2 on autonomous mode about datum	5 Sec	9.4.1.4
581	TN	Monitor message regarding VTUAV 2 on autonomous mode	5 Sec	9.2.1.7
582	UO	Receive message regarding VTUAV 2 on autonomous mode	5 Sec	9.2.1.6
584	UO	Monitor site of explosion with all available video sensors	Cont.	7.3.5.2
590	TN	Prepare for handover of VTUAV 2 to the CPF	12 Sec	7.1.1.11

ANNEX J

UAV SCENARIO GOAL MEAN COMPLETION TIMES – IP/PCT NETWORK PARTS 1, 2 AND 3

14 June 2004

ANNEX J
UAV SCENARIO GOAL MEAN COMPLETION TIMES (GOAL START AND END TIMES) – IP/PCT NETWORK PARTS 1, 2 AND 3

J.1.0 GENERAL

This annex contains the goal completion times for the UAV scenario networks (Annex F) as run within the IP/PCT mode of IPME. The scenario consists of three parts, and results are provided for each part with the IAI augmentation mode selected both ON and OFF. The model was run 10 times and in this annex the output for each run (goal start time and goal completion time) is provided along with the goal mean completion time.

J.1.1 UAV SCENARIO PART 1 – IAI AUGMENTATION SELECTED TO OFF

```
Goal Designation Number: (...140)
Run  1   42.4    85.0
Run  2   45.0    81.4
Run  3   48.0    90.1
Run  4   34.6    77.8
Run  5   42.0    82.6
Run  6   36.9    92.0
Run  7   43.8   107.4
Run  8   40.9   111.2
Run  9   40.9    87.1
Run 10   32.5    70.3
       ------  ------
         40.7    88.5
Goal Mean Completion Time:   47.8 Sec

Goal Designation Number: (...142)
Run  1   16.0    22.4
Run  2   16.0    21.2
Run  3   18.7    22.6
Run  4   14.6    19.4
Run  5   17.5    22.4
Run  6   11.7    18.9
Run  7   15.1    22.1
Run  8   15.9    21.7
Run  9   15.4    20.5
Run 10   11.5    15.4
       ------  ------
         15.3    20.7
Goal Mean Completion Time:    5.4 Sec
```

```
Goal Designation Number: (...144)
 Run  1   25.7   863.5
 Run  2   33.4   849.0
 Run  3   24.9   911.8
 Run  4   21.4   893.5
 Run  5   35.1   826.6
 Run  6   29.3   874.2
 Run  7   34.8   867.2
 Run  8   27.8   875.8
 Run  9   43.3   853.3
 Run 10   33.2   875.2
        ------  ------
          30.9   869.0
 Goal Mean Completion Time:  838.1 Sec

 Goal Designation Number: (...150)
 Run  1   16.0    94.2
 Run  2   16.0   109.1
 Run  3   18.7    99.0
 Run  4   14.6    78.3
 Run  5   17.5    94.0
 Run  6   11.7    87.6
 Run  7   15.1    98.4
 Run  8   15.9    96.2
 Run  9   15.4    78.1
 Run 10   11.5    90.9
        ------  ------
          15.3    92.6
 Goal Mean Completion Time:   77.3 Sec

 Goal Designation Number: (...153)
 Run  1    0.0    33.0
 Run  2    0.0    36.0
 Run  3    0.0    24.0
 Run  4    0.0    26.5
 Run  5    0.0    27.1
 Run  6    0.0    33.4
 Run  7    0.0    28.6
 Run  8    0.0    26.0
 Run  9    0.0    37.6
 Run 10    0.0    32.3
        ------  ------
           0.0    30.4
 Goal Mean Completion Time:   30.4 Sec
```

```
Goal Designation Number: (...154)
Run  1    5.7    39.9
Run  2    6.1    47.7
Run  3    7.5    31.2
Run  4    5.5    40.8
Run  5    5.5    37.1
Run  6    3.5    43.1
Run  7    2.8    38.6
Run  8    4.9    36.3
Run  9    4.9    44.6
Run 10    4.6    46.6
       ------  ------
          5.1    40.6
Goal Mean Completion Time:   35.5 Sec

Goal Designation Number: (...159)
Run  1   21.1    80.4
Run  2   17.2    71.2
Run  3   19.1    67.4
Run  4   24.2    79.7
Run  5   21.5    69.2
Run  6   17.8    67.8
Run  7   23.1    83.6
Run  8   22.6    71.6
Run  9   21.7    80.3
Run 10   25.5    91.3
       ------  ------
         21.4    76.3
Goal Mean Completion Time:   54.9 Sec

Goal Designation Number: (...170)
Run  1   22.4   207.2
Run  2   21.2   206.7
Run  3   22.6   190.2
Run  4   19.4   206.7
Run  5   22.4   189.8
Run  6   18.9   187.2
Run  7   22.1   202.9
Run  8   21.7   210.6
Run  9   20.5   209.4
Run 10   15.4   204.3
       ------  ------
         20.7   201.5
Goal Mean Completion Time:  180.8 Sec
```

```
Goal Designation Number: (...212)
Run  1   85.0   188.0
Run  2   81.4   177.8
Run  3   90.1   198.7
Run  4   77.8   232.7
Run  5   82.6   185.3
Run  6   92.0   220.3
Run  7  107.4   240.6
Run  8  111.2   212.1
Run  9   87.1   191.7
Run 10   70.3   276.8
       ------  ------
         88.5   212.4
Goal Mean Completion Time:  123.9 Sec

Goal Designation Number: (...234)
Run  1  211.4   329.1
Run  2  210.9   321.1
Run  3  211.6   319.5
Run  4  208.4   325.9
Run  5  211.3   334.0
Run  6  207.8   328.4
Run  7  211.5   319.8
Run  8  210.6   321.4
Run  9  209.4   329.7
Run 10  204.3   309.5
       ------  ------
        209.7   323.8
Goal Mean Completion Time:  114.1 Sec

Goal Designation Number: (...246)
Run  1   66.0   138.5
Run  2   64.9   149.8
Run  3   58.4   128.6
Run  4   64.3   171.1
Run  5   61.9   166.7
Run  6   69.9   178.4
Run  7   58.5   138.7
Run  8   60.9   118.6
Run  9   75.1   159.7
Run 10   81.0   164.0
       ------  ------
         66.1   151.4
Goal Mean Completion Time:   85.3 Sec
```

```
Goal Designation Number: (...274)
 Run  1  329.1   488.7
 Run  2  321.1   484.3
 Run  3  318.6   482.4
 Run  4  325.9   487.8
 Run  5  334.0   496.2
 Run  6  328.4   490.6
 Run  7  316.0   478.9
 Run  8  321.4   480.7
 Run  9  329.7   491.9
 Run 10  309.3   470.8
        ------  ------
         323.3   485.2
 Goal Mean Completion Time:  161.9 Sec

 Goal Designation Number: (...282)
 Run  1  168.2   223.2
 Run  2  149.2   202.2
 Run  3  198.7   257.0
 Run  4  190.7   240.6
 Run  5  181.2   254.0
 Run  6  211.7   267.5
 Run  7  208.3   259.9
 Run  8  201.8   259.0
 Run  9  191.7   238.8
 Run 10  238.8   287.6
        ------  ------
         194.0   249.0
 Goal Mean Completion Time:   55.0 Sec

 Goal Designation Number: (...294)
 Run  1  182.8   240.5
 Run  2  163.3   231.9
 Run  3  216.6   286.1
 Run  4  204.6   272.3
 Run  5  197.0   254.3
 Run  6  230.3   299.0
 Run  7  218.8   286.4
 Run  8  220.6   290.7
 Run  9  202.1   271.3
 Run 10  252.3   313.6
        ------  ------
         208.8   274.6
 Goal Mean Completion Time:   65.8 Sec
```

```
Goal Designation Number: (...296)
Run  1  213.9   473.2
Run  2  195.7   491.4
Run  3  248.2   481.1
Run  4  232.7   527.5
Run  5  225.9   504.0
Run  6  259.6   548.2
Run  7  250.2   529.3
Run  8  250.7   561.3
Run  9  231.3   504.0
Run 10  280.9   546.6
       ------  ------
        238.9   516.7
Goal Mean Completion Time:  277.8 Sec

Goal Designation Number: (...340)
Run  1  356.7   381.2
Run  2  352.3   385.4
Run  3  350.4   381.2
Run  4  355.8   393.2
Run  5  364.2   401.7
Run  6  358.6   383.5
Run  7  346.9   378.7
Run  8  348.7   384.7
Run  9  359.9   393.0
Run 10  338.8   367.9
       ------  ------
        353.2   385.1
Goal Mean Completion Time:   31.8 Sec

Goal Designation Number: (...374)
Run  1  213.9   564.0
Run  2  195.7   547.2
Run  3  248.2   592.4
Run  4  232.7   579.8
Run  5  225.9   573.7
Run  6  259.6   599.8
Run  7  250.2   593.4
Run  8  250.7   601.8
Run  9  231.3   571.0
Run 10  280.9   627.7
       ------  ------
        238.9   585.1
Goal Mean Completion Time:  346.2 Sec
```

```
Goal Designation Number: (...376)
Run  1  523.7   657.9
Run  2  507.6   610.6
Run  3  557.8   675.2
Run  4  541.9   651.8
Run  5  534.7   643.7
Run  6  569.8   670.6
Run  7  560.1   653.6
Run  8  561.3   690.8
Run  9  538.3   590.1
Run 10  588.0   647.7
       ------  ------
        548.3   649.2
Goal Mean Completion Time:  100.9 Sec

Goal Designation Number: (...386)
Run  1  582.4   666.5
Run  2  560.7   646.4
Run  3  613.2   700.8
Run  4  598.1   667.2
Run  5  588.8   669.8
Run  6  612.1   704.3
Run  7  606.2   685.8
Run  8  619.4   690.8
Run  9  583.8   639.7
Run 10  642.3   691.8
       ------  ------
        600.7   676.3
Goal Mean Completion Time:   75.6 Sec

Goal Designation Number: (...400)
Run  1  666.5   748.6
Run  2  646.4   728.2
Run  3  700.8   794.5
Run  4  667.2   763.5
Run  5  669.8   757.2
Run  6  704.3   792.7
Run  7  685.8   763.7
Run  8  690.8   768.8
Run  9  639.7   725.2
Run 10  691.8   772.9
       ------  ------
        676.3   761.5
Goal Mean Completion Time:   85.2 Sec
```

```
Goal Designation Number: (...416)
Run  1  363.7   539.4
Run  2  359.3   524.8
Run  3  357.4   518.0
Run  4  362.8   532.4
Run  5  371.2   537.5
Run  6  365.6   531.7
Run  7  353.9   513.1
Run  8  355.7   524.1
Run  9  366.9   542.0
Run 10  345.8   506.5
       ------  ------
        360.2   527.0
Goal Mean Completion Time:  166.7 Sec

Goal Designation Number: (...452)
Run  1  742.6   808.5
Run  2  722.2   799.3
Run  3  788.5   868.9
Run  4  758.5   838.6
Run  5  752.2   824.7
Run  6  786.7   871.4
Run  7  757.7   850.0
Run  8  762.8   780.9
Run  9  720.2   801.0
Run 10  767.9   869.5
       ------  ------
        755.9   831.3
Goal Mean Completion Time:   75.4 Sec

Goal Designation Number: (...456)
Run  1  747.6   831.1
Run  2  727.2   819.7
Run  3  793.5   878.7
Run  4  763.5   864.8
Run  5  757.2   842.1
Run  6  791.7   897.6
Run  7  762.7   854.1
Run  8  767.8   861.0
Run  9  725.2   801.0
Run 10  772.9   871.4
       ------  ------
        760.9   852.1
Goal Mean Completion Time:   91.2 Sec
```

```
Goal Designation Number: (...470)
Run  1  831.1   845.9
Run  2  819.7   832.8
Run  3  878.7   893.6
Run  4  864.8   876.0
Run  5  842.1   849.9
Run  6  897.6   910.4
Run  7  854.1   863.4
Run  8  861.0   875.4
Run  9  801.0   817.8
Run 10  871.4   885.9
       ------  ------
        852.1   865.1
Goal Mean Completion Time:   13.0 Sec

Goal Designation Number: (...486)
Run  1  842.6   876.9
Run  2  830.8   862.1
Run  3  891.4   920.3
Run  4  873.3   904.6
Run  5  847.2   890.8
Run  6  907.7   934.5
Run  7  861.1   888.7
Run  8  872.3   903.6
Run  9  815.2   854.7
Run 10  882.2   914.9
       ------  ------
        862.4   895.1
Goal Mean Completion Time:   32.7 Sec
```

J.1.2 UAV SCENARIO PART 1 – IAI AUGMENTATION SELECTED TO ON

```
Goal Designation Number: (...140)
 Run  1   29.7    45.5
 Run  2   28.2    43.8
 Run  3   31.9    52.6
 Run  4   34.8    72.2
 Run  5   29.7    49.0
 Run  6   25.1    41.0
 Run  7   35.1    59.3
 Run  8   29.6    45.1
 Run  9   26.1    58.5
 Run 10   27.0    43.0
        ------  ------
          29.7    51.0
 Goal Mean Completion Time:   21.3 Sec
```

```
Goal Designation Number: (...142)
Run  1   16.0    22.4
Run  2   14.5    20.3
Run  3   17.3    24.7
Run  4   17.0    25.5
Run  5   16.2    20.6
Run  6   14.8    17.9
Run  7   18.3    24.8
Run  8   13.8    22.1
Run  9   12.7    18.5
Run 10   17.6    19.7
       ------  ------
         15.8    21.6
Goal Mean Completion Time:    5.8 Sec

Goal Designation Number: (...144)
Run  1   25.7   723.4
Run  2   26.6   723.3
Run  3   33.9   701.3
Run  4   40.0   715.0
Run  5   22.5   727.0
Run  6   20.3   709.3
Run  7   28.1   689.3
Run  8   29.1   603.8
Run  9   32.4   693.3
Run 10   27.7   714.2
       ------  ------
         28.6   700.0
Goal Mean Completion Time:  671.4 Sec

Goal Designation Number: (...150)
Run  1   16.0   102.5
Run  2   14.5    99.2
Run  3   17.3    93.9
Run  4   17.0    92.1
Run  5   16.2    86.6
Run  6   14.8    83.2
Run  7   18.3    93.3
Run  8   13.8    81.5
Run  9   12.7    76.0
Run 10   17.6   112.7
       ------  ------
         15.8    92.1
Goal Mean Completion Time:   76.3 Sec
```

```
Goal Designation Number: (...153)
Run  1    0.0    33.0
Run  2    0.0    29.2
Run  3    0.0    32.5
Run  4    0.0    29.7
Run  5    0.0    28.8
Run  6    0.0    28.5
Run  7    0.0    27.8
Run  8    0.0    23.4
Run  9    0.0    28.0
Run 10    0.0    24.8
       ------  ------
          0.0    28.6
Goal Mean Completion Time:   28.6 Sec

Goal Designation Number: (...154)
Run  1    5.7    40.4
Run  2    5.6    39.1
Run  3    5.4    38.6
Run  4    4.6    41.7
Run  5    4.2    40.0
Run  6    6.1    35.4
Run  7    8.0    36.3
Run  8    3.6    32.2
Run  9    3.4    55.3
Run 10    7.4    35.3
       ------  ------
          5.4    39.4
Goal Mean Completion Time:   34.0 Sec

Goal Designation Number: (...159)
Run  1   21.1    80.4
Run  2   24.4    83.4
Run  3   20.6    73.6
Run  4   19.7    67.5
Run  5   21.6    80.1
Run  6   24.9    82.2
Run  7   23.4    84.6
Run  8   22.5    80.5
Run  9   25.7    80.2
Run 10   22.1    88.5
       ------  ------
         22.6    80.1
Goal Mean Completion Time:   57.5 Sec
```

```
Goal Designation Number: (...170)
Run  1   22.4   197.5
Run  2   20.3   184.9
Run  3   24.7   190.9
Run  4   25.5   200.1
Run  5   20.6   199.3
Run  6   17.9   201.1
Run  7   24.8   207.8
Run  8   22.1   184.2
Run  9   18.5   192.9
Run 10   19.7   196.0
       ------  ------
         21.6   195.5
Goal Mean Completion Time:  173.8 Sec

Goal Designation Number: (...212)
Run  1   45.5   188.5
Run  2   43.8   173.6
Run  3   52.6   224.0
Run  4   72.2   202.0
Run  5   49.0   205.8
Run  6   41.0   174.5
Run  7   59.3   145.9
Run  8   45.1   150.4
Run  9   58.5   162.5
Run 10   43.0   220.3
       ------  ------
         51.0   184.7
Goal Mean Completion Time:  133.7 Sec

Goal Designation Number: (...234)
Run  1  205.7   331.0
Run  2  203.6   323.0
Run  3  207.9   321.5
Run  4  208.5   330.0
Run  5  202.6   309.5
Run  6  201.1   319.7
Run  7  207.8   317.3
Run  8  204.4   317.6
Run  9  201.7   318.8
Run 10  203.0   311.6
       ------  ------
        204.6   320.0
Goal Mean Completion Time:  115.4 Sec
```

```
Goal Designation Number: (...246)
Run  1   66.2   144.2
Run  2   64.2   134.9
Run  3   63.6   157.8
Run  4   70.3   142.5
Run  5   55.3   158.4
Run  6   61.3   156.0
Run  7   65.5   151.2
Run  8   62.6   141.5
Run  9   48.0   170.6
Run 10   59.3   124.8
       ------  ------
         61.6   148.2
Goal Mean Completion Time:   86.6 Sec

Goal Designation Number: (...274)
Run  1  327.0   477.0
Run  2  319.0   472.5
Run  3  315.7   467.8
Run  4  325.5   477.4
Run  5  304.9   457.9
Run  6  315.4   468.3
Run  7  313.3   466.6
Run  8  312.6   463.5
Run  9  314.8   468.0
Run 10  306.9   460.7
       ------  ------
        315.5   468.0
Goal Mean Completion Time:  152.5 Sec

Goal Designation Number: (...282)
Run  1  176.6   234.5
Run  2  172.2   219.8
Run  3  183.6   236.0
Run  4  181.2   225.9
Run  5  184.3   228.3
Run  6  174.5   233.2
Run  7  145.9   201.6
Run  8  130.7   186.2
Run  9  147.2   197.7
Run 10  180.2   237.5
       ------  ------
        167.6   220.1
Goal Mean Completion Time:   52.4 Sec
```

```
Goal Designation Number: (...294)
Run  1  192.3   255.1
Run  2  185.7   252.6
Run  3  197.8   264.0
Run  4  193.4   251.6
Run  5  191.8   251.5
Run  6  194.0   260.6
Run  7  164.4   223.4
Run  8  148.6   208.6
Run  9  161.3   231.7
Run 10  195.0   255.0
       ------  ------
        182.4   245.4
Goal Mean Completion Time:   63.0 Sec

Goal Designation Number: (...296)
Run  1  224.8   520.5
Run  2  213.2   517.8
Run  3  226.3   510.4
Run  4  218.9   532.9
Run  5  220.6   468.2
Run  6  223.5   521.6
Run  7  193.1   465.2
Run  8  177.7   473.5
Run  9  191.7   428.6
Run 10  225.8   533.7
       ------  ------
        211.6   497.2
Goal Mean Completion Time:  285.6 Sec

Goal Designation Number: (...340)
Run  1  345.0   380.6
Run  2  340.5   368.7
Run  3  335.8   373.5
Run  4  345.4   373.1
Run  5  325.9   359.0
Run  6  336.3   368.6
Run  7  334.6   389.0
Run  8  331.5   364.6
Run  9  336.0   371.9
Run 10  328.7   355.0
       ------  ------
        336.0   370.4
Goal Mean Completion Time:   34.4 Sec
```

```
Goal Designation Number: (...374)
Run  1  224.8   571.7
Run  2  213.2   560.9
Run  3  226.3   567.4
Run  4  218.9   574.5
Run  5  220.6   563.0
Run  6  223.5   572.4
Run  7  193.1   535.8
Run  8  177.7   518.1
Run  9  191.7   539.6
Run 10  225.8   571.0
       ------  ------
        211.6   557.4
Goal Mean Completion Time:  345.9 Sec

Goal Designation Number: (...376)
Run  1  537.7   580.7
Run  2  521.6   564.9
Run  3  538.4   576.8
Run  4  534.8   584.3
Run  5  524.6   568.0
Run  6  532.9   579.6
Run  7  498.0   543.0
Run  8  492.3   526.3
Run  9  503.1   546.2
Run 10  535.0   577.6
       ------  ------
        521.8   564.7
Goal Mean Completion Time:   42.9 Sec

Goal Designation Number: (...386)
Run  1  573.7   590.4
Run  2  562.9   576.5
Run  3  569.4   581.9
Run  4  576.5   593.3
Run  5  565.0   576.2
Run  6  574.4   589.8
Run  7  537.8   554.8
Run  8  520.1   533.7
Run  9  541.6   557.2
Run 10  573.0   590.5
       ------  ------
        559.4   574.4
Goal Mean Completion Time:   15.0 Sec
```

```
Goal Designation Number: (...400)
Run  1  590.4   642.0
Run  2  576.5   621.8
Run  3  581.9   624.9
Run  4  593.3   644.9
Run  5  576.2   624.8
Run  6  589.8   637.9
Run  7  554.8   602.7
Run  8  533.7   579.9
Run  9  557.2   604.8
Run 10  590.5   633.7
       ------  ------
        574.4   621.7
Goal Mean Completion Time:   47.3 Sec

Goal Designation Number: (...416)
Run  1  352.0   518.4
Run  2  347.5   513.6
Run  3  342.8   507.9
Run  4  352.4   511.5
Run  5  332.9   504.8
Run  6  343.3   490.7
Run  7  341.6   515.7
Run  8  338.5   515.7
Run  9  343.0   501.6
Run 10  335.7   493.0
       ------  ------
        343.0   507.3
Goal Mean Completion Time:  164.3 Sec

Goal Designation Number: (...452)
Run  1  641.0   688.5
Run  2  620.8   716.2
Run  3  623.9   683.1
Run  4  643.9   726.3
Run  5  623.8   646.1
Run  6  636.9   706.1
Run  7  601.7   695.3
Run  8  578.9   601.1
Run  9  603.8   680.0
Run 10  632.7   705.4
       ------  ------
        620.7   684.8
Goal Mean Completion Time:   64.1 Sec
```

```
Goal Designation Number: (...456)
Run  1  642.0   736.2
Run  2  621.8   720.6
Run  3  624.9   720.8
Run  4  644.9   731.2
Run  5  624.8   720.3
Run  6  637.9   729.9
Run  7  602.7   717.7
Run  8  579.9   650.5
Run  9  604.8   691.1
Run 10  633.7   723.3
       ------  ------
        621.7   714.2
Goal Mean Completion Time:   92.4 Sec

Goal Designation Number: (...470)
Run  1  736.2   747.5
Run  2  720.6   735.3
Run  3  720.8   735.9
Run  4  731.2   745.9
Run  5  720.3   727.9
Run  6  729.9   744.7
Run  7  717.7   730.7
Run  8  650.5   660.7
Run  9  691.1   704.8
Run 10  723.3   728.4
       ------  ------
        714.2   726.2
Goal Mean Completion Time:   12.0 Sec

Goal Designation Number: (...486)
Run  1  743.0   760.5
Run  2  731.4   745.2
Run  3  732.2   751.6
Run  4  744.0   756.6
Run  5  724.8   738.8
Run  6  740.8   764.6
Run  7  728.9   742.5
Run  8  659.6   675.1
Run  9  701.3   718.6
Run 10  725.8   743.0
       ------  ------
        723.2   739.7
Goal Mean Completion Time:   16.5 Sec
```

J.1.3 UAV SCENARIO PART 2 – IAI AUGMENTATION SELECTED TO OFF

```
Goal Designation Number: (...120)
Run  1    0.0    86.2
Run  2    0.0   101.3
Run  3    0.0    89.5
Run  4    0.0   100.9
Run  5    0.0   106.1
Run  6    0.0    93.5
Run  7    0.0    88.9
Run  8    0.0    96.3
Run  9    0.0    91.1
Run 10    0.0    85.7
       ------  ------
          0.0    93.9
Goal Mean Completion Time:   93.9 Sec

Goal Designation Number: (...134)
Run  1    0.0   541.0
Run  2    0.0   541.0
Run  3    0.0   541.0
Run  4    0.0   541.0
Run  5    0.0   540.7
Run  6    0.0   541.0
Run  7    0.0   541.0
Run  8    0.0   541.0
Run  9    0.0   541.0
Run 10    0.0   541.0
       ------  ------
          0.0   541.0
Goal Mean Completion Time:  541.0 Sec

Goal Designation Number: (...136)
Run  1    0.0   105.5
Run  2    0.0    76.8
Run  3    0.0    63.4
Run  4    0.0    72.0
Run  5    0.0    76.0
Run  6    0.0    73.3
Run  7    0.0    91.3
Run  8    0.0    81.8
Run  9    0.0    91.1
Run 10    0.0    79.6
       ------  ------
          0.0    81.1
Goal Mean Completion Time:   81.1 Sec
```

```
Goal Designation Number: (...170)
Run  1   85.2   126.8
Run  2  100.3   124.7
Run  3   88.5   109.2
Run  4   99.9   132.4
Run  5  105.1   125.4
Run  6   92.5   130.0
Run  7   87.9   108.6
Run  8   95.3   132.2
Run  9   90.1   127.8
Run 10   84.7   113.0
       ------  ------
         92.9   123.0
Goal Mean Completion Time:   30.1 Sec

Goal Designation Number: (...180)
Run  1   90.8   437.8
Run  2  105.3   452.3
Run  3   93.5   440.5
Run  4  104.9   451.9
Run  5  110.1   456.8
Run  6   97.5   444.5
Run  7   92.9   439.9
Run  8  100.3   447.3
Run  9   95.1   442.1
Run 10   89.7   436.7
       ------  ------
         98.0   445.0
Goal Mean Completion Time:  347.0 Sec

Goal Designation Number: (...206)
Run  1  164.9   200.9
Run  2  178.7   218.4
Run  3  144.2   207.5
Run  4  140.4   200.1
Run  5  140.6   204.1
Run  6  142.0   214.3
Run  7  122.5   163.3
Run  8  145.4   208.6
Run  9  138.6   209.7
Run 10  148.1   213.7
       ------  ------
        146.6   204.1
Goal Mean Completion Time:   57.5 Sec
```

```
Goal Designation Number: (...330)
Run  1  110.7   209.1
Run  2  110.1   205.4
Run  3  110.9   217.6
Run  4  110.4   220.5
Run  5  109.7   252.6
Run  6  109.5   209.7
Run  7  113.1   214.8
Run  8  108.6   206.7
Run  9  112.7   206.3
Run 10  111.5   199.1
       ------  ------
        110.7   214.2
Goal Mean Completion Time:  103.4 Sec

Goal Designation Number: (...360)
Run  1  383.3   542.6
Run  2  445.9   637.8
Run  3  375.1   557.7
Run  4  441.8   646.0
Run  5  425.6   617.9
Run  6  482.1   673.1
Run  7  437.6   632.2
Run  8  439.7   648.2
Run  9  473.4   641.2
Run 10  408.9   620.1
       ------  ------
        431.3   621.7
Goal Mean Completion Time:  190.3 Sec

Goal Designation Number: (...374)
Run  1  556.8   870.8
Run  2  571.3   873.7
Run  3  559.5   863.5
Run  4  570.9   877.8
Run  5  575.8   887.1
Run  6  563.5   862.3
Run  7  558.9   865.3
Run  8  566.3   880.7
Run  9  561.1   869.3
Run 10  555.7   863.3
       ------  ------
        564.0   871.4
Goal Mean Completion Time:  307.4 Sec
```

```
Goal Designation Number: (...410)
Run  1  147.0   183.0
Run  2  153.2   191.7
Run  3  157.3   186.0
Run  4  136.3   171.6
Run  5  143.7   170.3
Run  6  137.7   196.7
Run  7  149.3   203.4
Run  8  138.4   180.4
Run  9  151.4   187.5
Run 10  150.8   199.1
       ------  ------
        146.5   187.0
Goal Mean Completion Time:   40.5 Sec

Goal Designation Number: (...416)
Run  1  187.9   294.6
Run  2  204.4   293.7
Run  3  203.0   275.5
Run  4  202.1   292.8
Run  5  251.6   312.4
Run  6  199.4   294.8
Run  7  213.8   290.6
Run  8  195.6   291.5
Run  9  205.3   300.8
Run 10  198.1   267.1
       ------  ------
        206.1   291.4
Goal Mean Completion Time:   85.2 Sec

Goal Designation Number: (...428)
Run  1  540.7   679.3
Run  2  636.8   713.8
Run  3  556.7   654.5
Run  4  643.7   728.3
Run  5  616.9   722.4
Run  6  672.1   756.3
Run  7  631.2   707.5
Run  8  647.2   722.4
Run  9  640.2   729.2
Run 10  619.1   701.7
       ------  ------
        620.5   711.5
Goal Mean Completion Time:   91.1 Sec
```

```
Goal Designation Number: (...447)
Run  1  293.6   376.7
Run  2  292.7   353.2
Run  3  274.5   349.1
Run  4  291.8   354.4
Run  5  311.4   398.0
Run  6  293.8   369.5
Run  7  289.6   354.9
Run  8  290.5   353.1
Run  9  299.8   373.6
Run 10  266.1   328.6
       ------  ------
        290.4   361.1
Goal Mean Completion Time:   70.8 Sec

Goal Designation Number: (...475)
Run  1  678.3  1023.4
Run  2  712.8  1055.1
Run  3  653.5   995.3
Run  4  727.3  1070.1
Run  5  721.4  1069.6
Run  6  755.3  1101.6
Run  7  706.5  1050.9
Run  8  721.4  1064.2
Run  9  728.2  1067.1
Run 10  700.7  1037.8
       ------  ------
        710.5  1053.5
Goal Mean Completion Time:  343.0 Sec

Goal Designation Number: (...500)
Run  1  375.7   603.7
Run  2  352.2   576.2
Run  3  348.1   554.1
Run  4  353.4   586.8
Run  5  397.0   631.4
Run  6  368.5   588.1
Run  7  353.9   600.9
Run  8  352.1   558.8
Run  9  372.6   597.6
Run 10  327.6   572.6
       ------  ------
        360.1   587.0
Goal Mean Completion Time:  226.9 Sec
```

```
Goal Designation Number: (...535)
Run  1  568.3   626.3
Run  2  553.6   600.9
Run  3  529.8   598.0
Run  4  545.9   593.4
Run  5  592.2   640.1
Run  6  560.1   611.9
Run  7  556.6   596.0
Run  8  535.2   581.2
Run  9  570.8   608.6
Run 10  538.8   586.3
       ------  ------
        555.1   604.3
Goal Mean Completion Time:   49.1 Sec

Goal Designation Number: (...546)
Run  1  869.8   961.1
Run  2  872.7   951.6
Run  3  862.5   940.8
Run  4  876.8   958.1
Run  5  886.1   971.2
Run  6  861.3   945.5
Run  7  864.3   955.0
Run  8  879.7   961.0
Run  9  868.3   950.2
Run 10  862.3   943.7
       ------  ------
        870.4   953.8
Goal Mean Completion Time:   83.4 Sec

Goal Designation Number: (...564)
Run  1  888.8  1093.8
Run  2  891.7  1096.7
Run  3  881.5  1086.5
Run  4  895.2  1100.2
Run  5  905.1  1110.1
Run  6  879.6  1084.6
Run  7  883.3  1088.3
Run  8  898.7  1104.2
Run  9  887.3  1092.3
Run 10  881.3  1086.3
       ------  ------
        889.3  1094.3
Goal Mean Completion Time:  205.0 Sec
```

```
Goal Designation Number: (...575)
Run  1  597.5   729.5
Run  2  596.3   739.8
Run  3  574.0   715.2
Run  4  585.4   722.9
Run  5  624.6   759.9
Run  6  602.1   716.5
Run  7  583.9   714.5
Run  8  573.5   692.7
Run  9  595.9   736.4
Run 10  570.2   696.8
       ------  ------
        590.3   722.4
Goal Mean Completion Time:  132.1 Sec

Goal Designation Number: (...600)
Run  1 1032.8  1050.8
Run  2 1035.7  1053.7
Run  3 1025.5  1042.8
Run  4 1039.2  1057.2
Run  5 1049.1  1067.1
Run  6 1023.6  1041.6
Run  7 1027.3  1044.3
Run  8 1042.7  1060.7
Run  9 1031.3  1049.3
Run 10 1025.3  1043.3
       ------  ------
       1033.2  1051.1
Goal Mean Completion Time:   17.8 Sec

Goal Designation Number: (...606)
Run  1 1092.8  1145.9
Run  2 1095.7  1162.5
Run  3 1085.5  1139.4
Run  4 1099.2  1159.2
Run  5 1109.1  1170.2
Run  6 1083.6  1146.1
Run  7 1087.3  1150.9
Run  8 1102.7  1166.1
Run  9 1091.3  1143.2
Run 10 1085.3  1154.7
       ------  ------
       1093.2  1153.8
Goal Mean Completion Time:   60.6 Sec
```

```
Goal Designation Number: (...630)
Run  1 1111.4  1143.3
Run  2 1119.9  1155.9
Run  3 1104.5  1140.1
Run  4 1121.8  1158.9
Run  5 1133.0  1168.4
Run  6 1102.6  1138.9
Run  7 1111.5  1142.1
Run  8 1126.8  1157.5
Run  9 1111.9  1143.3
Run 10 1108.5  1139.8
       ------  ------
       1115.2  1148.8
Goal Mean Completion Time:   33.6 Sec

Goal Designation Number: (...640)
Run  1 1022.4  1069.2
Run  2 1054.1  1107.4
Run  3  994.3  1037.8
Run  4 1067.9  1107.3
Run  5 1068.6  1113.0
Run  6 1100.6  1138.6
Run  7 1049.9  1096.6
Run  8 1063.2  1109.7
Run  9 1066.1  1104.7
Run 10 1036.8  1083.1
       ------  ------
       1052.4  1096.8
Goal Mean Completion Time:   44.4 Sec

Goal Designation Number: (...660)
Run  1 1056.4  1093.4
Run  2 1084.7  1130.4
Run  3 1025.3  1063.9
Run  4 1098.5  1143.3
Run  5 1096.8  1142.0
Run  6 1128.9  1167.9
Run  7 1076.9  1122.5
Run  8 1094.2  1139.5
Run  9 1097.3  1140.4
Run 10 1070.7  1115.0
       ------  ------
       1083.0  1125.8
Goal Mean Completion Time:   42.9 Sec
```

J.1.4 UAV SCENARIO PART 2 – IAI AUGMENTATION SELECTED TO ON

```
Goal Designation Number: (...120)
Run  1    0.0    40.1
Run  2    0.0    43.2
Run  3    0.0    45.6
Run  4    0.0    28.6
Run  5    0.0    52.6
Run  6    0.0    40.6
Run  7    0.0    46.7
Run  8    0.0    45.7
Run  9    0.0    20.3
Run 10    0.0    48.5
       ------  ------
          0.0    41.2
Goal Mean Completion Time:   41.2 Sec

Goal Designation Number: (...134)
Run  1    0.0   541.0
Run  2    0.0   541.0
Run  3    0.0   541.0
Run  4    0.0   541.0
Run  5    0.0   541.0
Run  6    0.0   541.0
Run  7    0.0   541.0
Run  8    0.0   541.0
Run  9    0.0   541.0
Run 10    0.0   541.0
       ------  ------
          0.0   541.0
Goal Mean Completion Time:  541.0 Sec

Goal Designation Number: (...136)
Run  1    0.0    42.4
Run  2    0.0    44.0
Run  3    0.0    44.0
Run  4    0.0    80.0
Run  5    0.0    51.0
Run  6    0.0    42.8
Run  7    0.0    46.9
Run  8    0.0    46.3
Run  9    0.0    66.1
Run 10    0.0    49.4
       ------  ------
          0.0    51.3
Goal Mean Completion Time:   51.3 Sec
```

```
Goal Designation Number: (...170)
Run  1   39.1    64.5
Run  2   42.2    60.9
Run  3   44.6    71.7
Run  4   27.6    52.4
Run  5   51.6    78.7
Run  6   39.6    66.8
Run  7   45.7    72.9
Run  8   44.7    68.8
Run  9   19.3    65.1
Run 10   47.5    71.3
       ------  ------
         40.2    67.3
Goal Mean Completion Time:   27.1 Sec

Goal Designation Number: (...180)
Run  1   46.1   393.1
Run  2   47.6   394.6
Run  3   49.6   396.6
Run  4   34.1   381.1
Run  5   56.6   403.6
Run  6   46.5   394.1
Run  7   50.7   397.7
Run  8   50.0   397.0
Run  9   24.8   371.8
Run 10   53.0   400.0
       ------  ------
         45.9   393.0
Goal Mean Completion Time:  347.1 Sec

Goal Designation Number: (...206)
Run  1   65.1   132.6
Run  2   61.5    96.6
Run  3   87.2   139.2
Run  4   79.6   127.2
Run  5  120.3   166.8
Run  6   96.2   127.2
Run  7  116.7   153.4
Run  8   99.5   131.1
Run  9   39.5    94.0
Run 10  106.2   137.6
       ------  ------
         87.2   130.6
Goal Mean Completion Time:   43.4 Sec
```

```
Goal Designation Number: (...330)
Run  1  101.7   166.9
Run  2   97.7   161.8
Run  3   99.6   164.1
Run  4  102.6   192.4
Run  5  100.7   176.5
Run  6   99.7   156.2
Run  7  101.9   153.2
Run  8   99.2   174.3
Run  9  101.6   151.1
Run 10  100.5   175.4
       ------  ------
        100.5   167.2
Goal Mean Completion Time:   66.7 Sec

Goal Designation Number: (...360)
Run  1  329.8   466.9
Run  2  368.0   510.4
Run  3  325.4   481.8
Run  4  311.4   498.4
Run  5  350.9   498.4
Run  6  355.5   489.9
Run  7  345.4   489.6
Run  8  339.6   496.1
Run  9  328.2   481.6
Run 10  359.8   504.4
       ------  ------
        341.4   491.8
Goal Mean Completion Time:  150.4 Sec

Goal Designation Number: (...374)
Run  1  512.1   811.1
Run  2  513.6   814.7
Run  3  515.6   835.5
Run  4  500.1   813.0
Run  5  522.6   833.0
Run  6  512.5   811.3
Run  7  516.7   832.6
Run  8  516.0   828.3
Run  9  490.8   791.3
Run 10  519.0   831.1
       ------  ------
        511.9   820.2
Goal Mean Completion Time:  308.3 Sec
```

```
Goal Designation Number: (...410)
Run  1  134.5   165.8
Run  2  134.5   182.4
Run  3  124.6   171.1
Run  4  129.2   169.8
Run  5  134.9   171.8
Run  6  121.8   155.9
Run  7  131.1   173.8
Run  8  120.0   152.8
Run  9  122.8   165.1
Run 10  122.4   161.0
       ------  ------
        127.6   166.9
Goal Mean Completion Time:   39.4 Sec

Goal Designation Number: (...416)
Run  1  165.9   204.2
Run  2  160.8   201.8
Run  3  154.0   211.0
Run  4  182.0   215.0
Run  5  153.4   223.5
Run  6  149.1   182.8
Run  7  144.8   191.0
Run  8  162.6   221.4
Run  9  139.2   189.6
Run 10  164.7   213.1
       ------  ------
        157.6   205.3
Goal Mean Completion Time:   47.7 Sec

Goal Designation Number: (...428)
Run  1  465.9   502.1
Run  2  509.4   551.5
Run  3  480.8   520.6
Run  4  497.4   538.6
Run  5  497.4   540.6
Run  6  488.9   530.0
Run  7  488.6   513.9
Run  8  495.1   525.3
Run  9  480.6   509.1
Run 10  503.4   541.8
       ------  ------
        490.8   527.4
Goal Mean Completion Time:   36.6 Sec
```

```
Goal Designation Number: (...447)
Run  1  203.2   237.3
Run  2  200.8   236.4
Run  3  210.0   244.9
Run  4  214.0   256.1
Run  5  222.5   255.6
Run  6  181.8   219.3
Run  7  190.0   224.1
Run  8  220.4   254.3
Run  9  188.6   220.0
Run 10  212.1   246.5
       ------  ------
        204.3   239.5
Goal Mean Completion Time:   35.1 Sec

Goal Designation Number: (...475)
Run  1  501.1   829.0
Run  2  550.5   869.5
Run  3  519.6   842.7
Run  4  537.6   858.6
Run  5  539.6   864.9
Run  6  529.0   852.9
Run  7  512.9   843.9
Run  8  524.3   847.6
Run  9  508.1   839.1
Run 10  540.8   866.3
       ------  ------
        526.4   851.5
Goal Mean Completion Time:  325.1 Sec

Goal Designation Number: (...500)
Run  1  236.3   370.1
Run  2  235.4   375.4
Run  3  243.9   388.6
Run  4  248.5   405.1
Run  5  254.6   412.0
Run  6  218.3   350.6
Run  7  223.1   381.3
Run  8  253.3   396.0
Run  9  219.0   362.4
Run 10  245.5   396.1
       ------  ------
        237.8   383.8
Goal Mean Completion Time:  146.0 Sec
```

```
Goal Designation Number: (...535)
Run  1  363.0   370.2
Run  2  367.3   376.1
Run  3  377.8   388.0
Run  4  396.2   408.2
Run  5  403.5   410.4
Run  6  342.4   349.2
Run  7  355.5   380.7
Run  8  383.1   396.7
Run  9  337.1   372.2
Run 10  376.9   393.3
       ------  ------
        370.3   384.5
Goal Mean Completion Time:   14.2 Sec

Goal Designation Number: (...546)
Run  1  810.1   885.8
Run  2  813.7   886.5
Run  3  834.5   903.2
Run  4  812.0   891.4
Run  5  832.0   912.9
Run  6  810.3   892.2
Run  7  831.6   910.8
Run  8  827.3   898.9
Run  9  790.3   869.6
Run 10  830.1   900.3
       ------  ------
        819.2   895.2
Goal Mean Completion Time:   76.0 Sec

Goal Designation Number: (...564)
Run  1  828.4  1033.4
Run  2  832.7  1037.7
Run  3  853.6  1059.5
Run  4  831.0  1036.0
Run  5  850.1  1055.1
Run  6  829.3  1034.3
Run  7  850.6  1055.7
Run  8  846.0  1051.0
Run  9  809.2  1014.2
Run 10  848.2  1053.2
       ------  ------
        837.9  1043.0
Goal Mean Completion Time:  205.1 Sec
```

```
Goal Designation Number: (...575)
Run  1  368.2   510.7
Run  2  373.7   505.4
Run  3  385.3   507.1
Run  4  406.5   526.9
Run  5  408.4   536.2
Run  6  347.1   469.0
Run  7  378.8   505.3
Run  8  395.0   512.2
Run  9  365.3   485.5
Run 10  386.7   516.5
       ------  ------
        381.5   507.5
Goal Mean Completion Time:  126.0 Sec

Goal Designation Number: (...600)
Run  1  972.4   990.4
Run  2  976.7   994.7
Run  3  998.5  1016.5
Run  4  975.0   993.0
Run  5  994.1  1012.1
Run  6  973.3   991.3
Run  7  994.7  1012.7
Run  8  990.0  1008.0
Run  9  953.2   971.2
Run 10  992.2  1010.2
       ------  ------
        982.0  1000.0
Goal Mean Completion Time:   18.0 Sec

Goal Designation Number: (...606)
Run  1 1032.4  1104.4
Run  2 1036.7  1104.2
Run  3 1058.5  1131.8
Run  4 1035.0  1104.4
Run  5 1054.1  1121.4
Run  6 1033.3  1103.4
Run  7 1054.7  1125.4
Run  8 1050.0  1112.2
Run  9 1013.2  1083.1
Run 10 1052.2  1114.0
       ------  ------
       1042.0  1110.4
Goal Mean Completion Time:   68.4 Sec
```

```
Goal Designation Number: (...630)
Run  1 1051.4  1080.6
Run  2 1055.7  1085.1
Run  3 1077.5  1106.7
Run  4 1054.0  1083.3
Run  5 1073.1  1102.6
Run  6 1052.3  1081.7
Run  7 1073.7  1103.1
Run  8 1069.0  1106.2
Run  9 1032.2  1061.4
Run 10 1071.2  1108.0
       ------  ------
       1061.0  1091.9
Goal Mean Completion Time:   30.9 Sec

Goal Designation Number: (...640)
Run  1  828.0   856.7
Run  2  868.5   894.0
Run  3  841.7   872.4
Run  4  857.6   878.8
Run  5  863.9   892.4
Run  6  851.9   883.6
Run  7  842.4   869.8
Run  8  846.6   874.8
Run  9  838.1   866.2
Run 10  864.9   893.0
       ------  ------
        850.4   878.2
Goal Mean Completion Time:   27.8 Sec

Goal Designation Number: (...660)
Run  1  847.6   884.6
Run  2  890.5   927.5
Run  3  858.6   898.6
Run  4  874.8   919.4
Run  5  879.1   925.9
Run  6  881.0   920.2
Run  7  864.7   910.8
Run  8  865.0   911.9
Run  9  862.0   905.6
Run 10  889.1   928.3
       ------  ------
        871.2   913.3
Goal Mean Completion Time:   42.0 Sec
```

J.1.5 UAV SCENARIO PART 3 – IAI AUGMENTATION SELECTED TO OFF

```
Goal Designation Number: (...120)
Run  1    0.0    96.7
Run  2    0.0    93.3
Run  3    0.0    90.5
Run  4    0.0    92.4
Run  5    0.0    98.4
Run  6    0.0    92.0
Run  7    0.0    97.2
Run  8    0.0    94.1
Run  9    0.0    94.3
Run 10    0.0   108.8
       ------  ------
          0.0    95.8
Goal Mean Completion Time:   95.8 Sec

Goal Designation Number: (...130)
Run  1    0.0   158.8
Run  2    0.0   184.4
Run  3    0.0   210.3
Run  4    0.0   152.5
Run  5    0.0   234.1
Run  6    0.0   187.3
Run  7    0.0   204.0
Run  8    0.0   237.6
Run  9    0.0   135.3
Run 10    0.0   237.4
       ------  ------
          0.0   194.2
Goal Mean Completion Time:  194.2 Sec

Goal Designation Number: (...132)
Run  1    0.0    81.5
Run  2    0.0    81.7
Run  3    0.0    79.2
Run  4    0.0    80.4
Run  5    0.0    79.1
Run  6    0.0    86.5
Run  7    0.0    79.0
Run  8    0.0    79.3
Run  9    0.0    73.6
Run 10    0.0    82.2
       ------  ------
          0.0    80.2
Goal Mean Completion Time:   80.2 Sec
```

```
Goal Designation Number: (...148)
Run  1    0.0   148.0
Run  2    0.0   155.8
Run  3    0.0   144.8
Run  4    0.0   142.9
Run  5    0.0   143.0
Run  6    0.0   142.1
Run  7    0.0   146.5
Run  8    0.0   152.0
Run  9    0.0   153.2
Run 10    0.0   143.6
       ------  ------
          0.0   147.2
Goal Mean Completion Time:  147.2 Sec

Goal Designation Number: (...164)
Run  1   80.5   131.0
Run  2   80.7   134.4
Run  3   78.2   131.4
Run  4   79.4   129.5
Run  5   78.1   128.8
Run  6   85.5   135.6
Run  7   78.0   133.5
Run  8   78.3   131.5
Run  9   72.6   121.4
Run 10   81.2   131.6
       ------  ------
         79.2   130.9
Goal Mean Completion Time:   51.6 Sec

Goal Designation Number: (...180)
Run  1  123.0   156.0
Run  2  122.3   156.3
Run  3  123.0   154.7
Run  4  122.0   155.6
Run  5  117.1   149.6
Run  6  129.1   162.0
Run  7  119.2   153.7
Run  8  122.6   157.0
Run  9  115.0   146.3
Run 10  126.4   160.4
       ------  ------
        122.0   155.2
Goal Mean Completion Time:   33.2 Sec
```

```
Goal Designation Number: (...192)
Run  1  142.1   178.5
Run  2  142.8   188.4
Run  3  142.6   179.4
Run  4  140.7   177.7
Run  5  137.2   181.9
Run  6  146.7   188.0
Run  7  141.9   180.1
Run  8  142.6   195.3
Run  9  132.6   172.3
Run 10  142.7   171.1
       ------  ------
        141.2   181.3
Goal Mean Completion Time:   40.1 Sec

Goal Designation Number: (...203)
Run  1  185.0   467.0
Run  2  185.3   467.3
Run  3  183.7   465.7
Run  4  184.6   466.6
Run  5  178.6   460.6
Run  6  191.0   473.0
Run  7  182.7   464.7
Run  8  186.0   468.0
Run  9  175.3   457.3
Run 10  189.4   471.4
       ------  ------
        184.2   466.2
Goal Mean Completion Time:  282.0 Sec

Goal Designation Number: (...207)
Run  1  211.0   225.8
Run  2  211.3   226.3
Run  3  209.7   224.3
Run  4  210.6   225.3
Run  5  204.6   219.6
Run  6  217.0   231.4
Run  7  208.7   223.7
Run  8  212.0   226.3
Run  9  201.3   216.0
Run 10  215.4   230.4
       ------  ------
        210.2   224.9
Goal Mean Completion Time:   14.7 Sec
```

```
Goal Designation Number: (...220)
Run  1  130.0   133.2
Run  2  133.4   136.6
Run  3  130.4   133.6
Run  4  128.5   131.7
Run  5  127.8   131.0
Run  6  134.6   137.8
Run  7  132.5   135.5
Run  8  130.5   133.7
Run  9  120.4   123.6
Run 10  130.6   133.8
       ------  ------
        129.9   133.1
Goal Mean Completion Time:    3.2 Sec

Goal Designation Number: (...230)
Run  1  130.4   227.4
Run  2  133.8   226.1
Run  3  130.8   222.2
Run  4  128.9   218.4
Run  5  128.2   223.2
Run  6  135.0   229.4
Run  7  132.9   222.5
Run  8  130.9   238.4
Run  9  120.8   213.0
Run 10  131.0   210.4
       ------  ------
        130.3   223.1
Goal Mean Completion Time:   92.8 Sec

Goal Designation Number: (...244)
Run  1  235.0   307.0
Run  2  235.6   307.3
Run  3  240.2   305.7
Run  4  238.3   306.6
Run  5  228.6   300.6
Run  6  241.1   308.5
Run  7  232.7   304.7
Run  8  239.0   310.9
Run  9  230.2   302.2
Run 10  239.5   310.4
       ------  ------
        236.0   306.4
Goal Mean Completion Time:   70.3 Sec
```

```
Goal Designation Number: (...260)
Run  1  204.8   315.0
Run  2  208.2   315.3
Run  3  205.2   313.4
Run  4  203.3   314.0
Run  5  202.6   308.6
Run  6  209.4   316.5
Run  7  207.1   312.7
Run  8  205.3   310.9
Run  9  195.2   302.2
Run 10  205.4   311.4
       ------  ------
        204.6   312.0
Goal Mean Completion Time:  107.3 Sec

Goal Designation Number: (...265)
Run  1  284.0   796.7
Run  2  284.3   767.6
Run  3  282.7   775.4
Run  4  283.6   775.8
Run  5  277.6   795.6
Run  6  290.0   806.1
Run  7  281.7   776.8
Run  8  285.0   770.2
Run  9  274.3   758.4
Run 10  288.4   770.0
       ------  ------
        283.2   779.3
Goal Mean Completion Time:  496.1 Sec

Goal Designation Number: (...278)
Run  1  211.8   264.5
Run  2  215.2   266.9
Run  3  212.2   265.0
Run  4  210.3   262.9
Run  5  209.6   260.7
Run  6  216.4   268.1
Run  7  214.1   267.4
Run  8  213.2   265.7
Run  9  203.0   255.2
Run 10  211.9   264.1
       ------  ------
        211.8   264.0
Goal Mean Completion Time:   52.3 Sec
```

```
Goal Designation Number: (...315)
Run  1  330.8   395.7
Run  2  334.2   393.8
Run  3  331.2   385.9
Run  4  329.3   385.0
Run  5  328.6   415.0
Run  6  335.4   393.0
Run  7  333.1   401.0
Run  8  331.3   414.1
Run  9  321.2   388.5
Run 10  331.4   392.9
       ------  ------
        330.6   396.5
Goal Mean Completion Time:   65.8 Sec

Goal Designation Number: (...325)
Run  1  345.8   439.4
Run  2  349.2   442.6
Run  3  346.2   461.8
Run  4  344.3   438.8
Run  5  343.6   452.6
Run  6  350.4   462.6
Run  7  348.1   458.9
Run  8  346.3   449.7
Run  9  336.2   437.9
Run 10  346.4   439.2
       ------  ------
        345.6   448.4
Goal Mean Completion Time:  102.7 Sec

Goal Designation Number: (...335)
Run  1  390.8   461.9
Run  2  394.2   447.0
Run  3  391.2   458.7
Run  4  389.3   440.8
Run  5  388.6   459.4
Run  6  395.4   467.8
Run  7  393.1   468.2
Run  8  391.3   457.0
Run  9  381.2   442.5
Run 10  391.4   443.0
       ------  ------
        390.6   454.6
Goal Mean Completion Time:   64.0 Sec
```

```
Goal Designation Number: (...355)
Run  1  426.8   452.8
Run  2  430.2   449.7
Run  3  427.2   461.8
Run  4  425.3   448.7
Run  5  424.6   461.2
Run  6  431.4   462.6
Run  7  429.1   458.9
Run  8  427.3   449.7
Run  9  417.2   440.0
Run 10  427.4   466.3
       ------  ------
        426.6   455.2
Goal Mean Completion Time:   28.5 Sec

Goal Designation Number: (...366)
Run  1  438.4   550.4
Run  2  441.6   569.7
Run  3  460.8   588.0
Run  4  437.8   509.0
Run  5  451.6   606.2
Run  6  461.6   605.4
Run  7  457.9   606.3
Run  8  448.7   547.3
Run  9  436.9   564.4
Run 10  438.2   547.2
       ------  ------
        447.4   569.4
Goal Mean Completion Time:  122.0 Sec

Goal Designation Number: (...368)
Run  1  466.0   484.8
Run  2  466.3   515.3
Run  3  464.7   494.3
Run  4  465.6   489.4
Run  5  459.6   500.6
Run  6  472.0   490.9
Run  7  463.7   497.0
Run  8  467.0   486.0
Run  9  456.3   476.6
Run 10  470.4   489.5
       ------  ------
        465.2   492.4
Goal Mean Completion Time:   27.3 Sec
```

```
Goal Designation Number: (...375)
Run  1  460.9   569.7
Run  2  444.6   554.7
Run  3  457.7   566.6
Run  4  438.5   556.3
Run  5  457.0   575.4
Run  6  466.8   580.3
Run  7  467.2   561.9
Run  8  455.3   560.5
Run  9  439.8   547.2
Run 10  439.5   551.9
       ------  ------
        452.7   562.5
Goal Mean Completion Time:  109.7 Sec

Goal Designation Number: (...385)
Run  1  472.3  1167.8
Run  2  475.7  1148.8
Run  3  472.7  1155.4
Run  4  470.8  1152.3
Run  5  470.1  1152.5
Run  6  476.9  1179.8
Run  7  474.6  1154.3
Run  8  472.8  1154.1
Run  9  462.7  1143.5
Run 10  472.9  1148.6
       ------  ------
        472.1  1155.7
Goal Mean Completion Time:  683.6 Sec

Goal Designation Number: (...410)
Run  1  535.1   587.4
Run  2  519.2   567.2
Run  3  531.0   578.2
Run  4  522.1   573.2
Run  5  541.2   591.8
Run  6  545.1   596.3
Run  7  527.5   578.8
Run  8  525.7   578.3
Run  9  511.9   564.7
Run 10  517.3   570.4
       ------  ------
        527.6   578.6
Goal Mean Completion Time:   51.0 Sec
```

```
Goal Designation Number: (...427)
Run  1  579.7   606.7
Run  2  561.9   589.6
Run  3  577.2   599.3
Run  4  565.1   598.6
Run  5  587.3   607.5
Run  6  592.9   615.0
Run  7  577.8   605.1
Run  8  577.0   598.1
Run  9  563.7   590.7
Run 10  569.4   593.5
       ------  ------
        575.2   600.4
Goal Mean Completion Time:   25.2 Sec

Goal Designation Number: (...438)
Run  1  605.7   620.7
Run  2  584.4   599.6
Run  3  598.3   613.3
Run  4  591.6   606.8
Run  5  606.5   621.5
Run  6  614.0   629.0
Run  7  600.0   615.2
Run  8  597.1   612.1
Run  9  584.8   600.0
Run 10  592.5   607.5
       ------  ------
        597.5   612.6
Goal Mean Completion Time:   15.1 Sec

Goal Designation Number: (...444)
Run  1  619.7   633.2
Run  2  598.4   611.9
Run  3  612.3   625.8
Run  4  605.6   619.0
Run  5  620.5   633.9
Run  6  628.0   641.4
Run  7  614.0   627.4
Run  8  611.1   624.6
Run  9  598.8   612.3
Run 10  606.5   620.0
       ------  ------
        611.5   624.9
Goal Mean Completion Time:   13.4 Sec
```

```
Goal Designation Number: (...456)
Run  1  619.7   636.2
Run  2  598.4   614.8
Run  3  612.3   628.8
Run  4  605.6   622.0
Run  5  620.5   636.9
Run  6  628.0   644.4
Run  7  614.0   630.4
Run  8  611.1   627.5
Run  9  598.8   615.3
Run 10  606.5   622.9
       ------  ------
        611.5   627.9
Goal Mean Completion Time:   16.4 Sec

Goal Designation Number: (...460)
Run  1  632.2  1076.8
Run  2  610.9  1051.0
Run  3  624.8  1066.2
Run  4  618.0  1056.0
Run  5  632.9  1072.3
Run  6  640.4  1082.5
Run  7  626.4  1067.6
Run  8  623.6  1068.3
Run  9  611.3  1056.0
Run 10  619.0  1062.6
       ------  ------
        623.9  1065.9
Goal Mean Completion Time:  442.0 Sec

Goal Designation Number: (...470)
Run  1  690.6   933.5
Run  2  673.9   856.4
Run  3  680.0   855.4
Run  4  681.0   918.2
Run  5  695.9   949.8
Run  6  702.1   903.2
Run  7  682.6   851.5
Run  8  680.3   874.9
Run  9  671.6   874.9
Run 10  676.4   864.1
       ------  ------
        683.4   888.2
Goal Mean Completion Time:  204.7 Sec
```

```
Goal Designation Number: (...490)
Run  1  820.2   871.6
Run  2  798.9   850.3
Run  3  812.8   864.2
Run  4  806.0   857.4
Run  5  820.9   872.3
Run  6  828.4   879.8
Run  7  814.4   865.8
Run  8  811.6   863.0
Run  9  799.3   850.7
Run 10  807.0   858.4
       ------  ------
        811.9   863.3
Goal Mean Completion Time:   51.4 Sec

Goal Designation Number: (...510)
Run  1  800.9   950.0
Run  2  784.2   918.6
Run  3  790.3   934.5
Run  4  791.3   930.0
Run  5  806.2   944.0
Run  6  812.4   956.1
Run  7  792.9   942.5
Run  8  790.6   940.0
Run  9  781.9   923.6
Run 10  786.7   930.4
       ------  ------
        793.7   937.0
Goal Mean Completion Time:  143.2 Sec

Goal Designation Number: (...524)
Run  1  795.7   996.9
Run  2  766.6   969.6
Run  3  774.4   983.8
Run  4  774.8   978.2
Run  5  794.6   992.4
Run  6  805.1  1005.9
Run  7  775.8   989.6
Run  8  769.2   989.1
Run  9  757.4   973.8
Run 10  769.0   977.9
       ------  ------
        778.3   985.7
Goal Mean Completion Time:  207.5 Sec
```

```
Goal Designation Number: (...526)
Run  1  836.2   923.4
Run  2  814.9   891.6
Run  3  828.8   907.5
Run  4  822.0   903.6
Run  5  836.9   917.2
Run  6  844.4   930.0
Run  7  830.4   915.5
Run  8  827.6   913.0
Run  9  815.3   896.6
Run 10  823.0   903.6
       ------  ------
        827.9   910.2
Goal Mean Completion Time:   82.3 Sec

Goal Designation Number: (...550)
Run  1  922.4  1004.1
Run  2  890.6   974.0
Run  3  906.5   988.2
Run  4  902.6   983.4
Run  5  916.2   997.5
Run  6  929.0  1010.1
Run  7  914.5   995.4
Run  8  912.0   995.1
Run  9  895.6   977.6
Run 10  902.6   983.5
       ------  ------
        909.2   990.9
Goal Mean Completion Time:   81.7 Sec

Goal Designation Number: (...556)
Run  1 1083.8  1137.6
Run  2 1058.0  1113.1
Run  3 1073.2  1126.9
Run  4 1063.0  1114.9
Run  5 1079.3  1138.0
Run  6 1089.5  1134.8
Run  7 1074.6  1124.3
Run  8 1075.3  1127.3
Run  9 1063.0  1115.5
Run 10 1069.6  1130.4
       ------  ------
       1072.9  1126.3
Goal Mean Completion Time:   53.3 Sec
```

```
Goal Designation Number: (...560)
Run  1  928.4  1084.8
Run  2  896.6  1059.0
Run  3  912.5  1074.2
Run  4  908.6  1064.0
Run  5  922.2  1080.3
Run  6  935.0  1090.5
Run  7  920.5  1075.6
Run  8  918.0  1076.3
Run  9  901.6  1064.0
Run 10  908.6  1070.6
       ------  ------
        915.2  1073.9
Goal Mean Completion Time:  158.7 Sec

Goal Designation Number: (...574)
Run  1 1107.8  1167.8
Run  2 1082.0  1148.8
Run  3 1097.2  1155.4
Run  4 1087.0  1152.3
Run  5 1103.3  1152.5
Run  6 1114.3  1179.8
Run  7 1098.6  1154.3
Run  8 1099.3  1154.1
Run  9 1087.0  1143.5
Run 10 1093.6  1148.6
       ------  ------
       1097.0  1155.7
Goal Mean Completion Time:   58.7 Sec
```

J.1.6 UAV SCENARIO PART 3 – IAI AUGMENTATION SELECTED TO ON

```
Goal Designation Number: (...120)
Run  1    0.0    99.1
Run  2    0.0    91.8
Run  3    0.0    95.4
Run  4    0.0    99.1
Run  5    0.0    98.9
Run  6    0.0   100.6
Run  7    0.0    90.0
Run  8    0.0    93.7
Run  9    0.0    88.9
Run 10    0.0   117.1
       ------  ------
          0.0    97.5
Goal Mean Completion Time:   97.5 Sec
```

```
Goal Designation Number: (...130)
Run  1    0.0   180.8
Run  2    0.0   172.2
Run  3    0.0   220.5
Run  4    0.0   159.5
Run  5    0.0   237.4
Run  6    0.0   138.9
Run  7    0.0   191.9
Run  8    0.0   210.0
Run  9    0.0   218.4
Run 10    0.0   165.4
       ------  ------
          0.0   189.5
Goal Mean Completion Time:  189.5 Sec

Goal Designation Number: (...132)
Run  1    0.0    84.1
Run  2    0.0    84.6
Run  3    0.0    78.0
Run  4    0.0    78.5
Run  5    0.0    87.2
Run  6    0.0    81.0
Run  7    0.0    73.0
Run  8    0.0    81.8
Run  9    0.0    77.1
Run 10    0.0    74.6
       ------  ------
          0.0    80.0
Goal Mean Completion Time:   80.0 Sec

Goal Designation Number: (...148)
Run  1    0.0   149.5
Run  2    0.0   151.8
Run  3    0.0   143.8
Run  4    0.0   140.2
Run  5    0.0   149.8
Run  6    0.0   148.5
Run  7    0.0   155.5
Run  8    0.0   151.4
Run  9    0.0   148.3
Run 10    0.0   154.1
       ------  ------
          0.0   149.3
Goal Mean Completion Time:  149.3 Sec
```

```
Goal Designation Number: (...164)
Run  1   83.1   127.7
Run  2   83.6   121.7
Run  3   77.0   122.8
Run  4   77.5   128.2
Run  5   86.2   125.6
Run  6   80.0   128.0
Run  7   72.0   123.7
Run  8   80.8   125.8
Run  9   76.1   123.2
Run 10   73.6   146.4
       ------  ------
         79.0   127.3
Goal Mean Completion Time:   48.3 Sec

Goal Designation Number: (...180)
Run  1  116.8   152.3
Run  2  115.4   149.8
Run  3  113.2   147.6
Run  4  116.2   152.7
Run  5  117.5   153.6
Run  6  118.8   154.4
Run  7  115.9   151.1
Run  8  113.7   149.4
Run  9  115.0   149.7
Run 10  136.1   171.0
       ------  ------
        117.9   153.1
Goal Mean Completion Time:   35.3 Sec

Goal Designation Number: (...192)
Run  1  136.1   176.5
Run  2  132.9   167.7
Run  3  134.0   185.9
Run  4  136.6   174.9
Run  5  136.8   186.6
Run  6  139.2   187.4
Run  7  134.9   188.3
Run  8  134.2   177.9
Run  9  134.3   166.2
Run 10  154.8   197.7
       ------  ------
        137.4   180.9
Goal Mean Completion Time:   43.5 Sec
```

```
Goal Designation Number: (...203)
Run  1  181.3   463.3
Run  2  178.8   460.8
Run  3  176.6   458.6
Run  4  181.7   463.7
Run  5  182.6   464.6
Run  6  183.4   465.4
Run  7  180.1   462.1
Run  8  178.4   460.4
Run  9  178.7   460.7
Run 10  200.0   482.0
       ------  ------
        182.1   464.1
Goal Mean Completion Time:  282.0 Sec

Goal Designation Number: (...207)
Run  1  207.3   221.5
Run  2  204.8   219.0
Run  3  202.6   216.6
Run  4  207.7   222.0
Run  5  208.6   223.5
Run  6  209.4   223.8
Run  7  206.1   221.0
Run  8  204.4   219.4
Run  9  204.7   219.0
Run 10  226.0   240.2
       ------  ------
        208.1   222.6
Goal Mean Completion Time:   14.4 Sec

Goal Designation Number: (...220)
Run  1  126.7   129.9
Run  2  120.7   123.9
Run  3  121.8   125.0
Run  4  127.2   130.4
Run  5  124.6   127.8
Run  6  127.0   130.2
Run  7  122.7   125.9
Run  8  124.8   128.0
Run  9  122.2   125.4
Run 10  145.4   148.6
       ------  ------
        126.3   129.5
Goal Mean Completion Time:    3.2 Sec
```

```
Goal Designation Number: (...230)
Run  1  127.1   186.8
Run  2  121.1   178.0
Run  3  122.2   196.2
Run  4  127.6   185.2
Run  5  125.0   196.9
Run  6  127.4   199.9
Run  7  123.1   198.6
Run  8  125.2   188.3
Run  9  122.6   176.5
Run 10  145.8   208.0
       ------  ------
        126.7   191.4
Goal Mean Completion Time:   64.7 Sec

Goal Designation Number: (...244)
Run  1  236.1   303.3
Run  2  230.5   300.5
Run  3  230.8   298.3
Run  4  235.4   303.7
Run  5  234.4   304.4
Run  6  235.5   305.4
Run  7  232.5   302.1
Run  8  234.2   302.5
Run  9  232.0   300.7
Run 10  251.7   308.0
       ------  ------
        235.3   302.9
Goal Mean Completion Time:   67.6 Sec

Goal Designation Number: (...260)
Run  1  201.5   300.1
Run  2  195.5   294.6
Run  3  196.6   294.8
Run  4  202.0   299.9
Run  5  199.4   298.3
Run  6  201.8   300.4
Run  7  197.5   295.9
Run  8  199.6   298.2
Run  9  197.0   295.6
Run 10  220.2   318.2
       ------  ------
        201.1   299.6
Goal Mean Completion Time:   98.5 Sec
```

```
Goal Designation Number: (...265)
Run  1  280.3   751.5
Run  2  277.8   738.7
Run  3  275.6   740.4
Run  4  280.7   744.8
Run  5  281.6   743.2
Run  6  282.4   749.5
Run  7  279.1   752.7
Run  8  277.4   753.5
Run  9  277.7   746.3
Run 10  299.0   782.0
       ------  ------
        281.1   750.3
Goal Mean Completion Time:  469.1 Sec

Goal Designation Number: (...278)
Run  1  208.5   239.0
Run  2  202.5   233.7
Run  3  203.6   236.1
Run  4  209.0   240.5
Run  5  206.0   237.1
Run  6  208.8   238.0
Run  7  204.5   235.1
Run  8  206.0   237.8
Run  9  204.0   235.3
Run 10  227.2   258.7
       ------  ------
        208.0   239.1
Goal Mean Completion Time:   31.1 Sec

Goal Designation Number: (...315)
Run  1  320.3   328.4
Run  2  314.3   322.4
Run  3  315.4   323.5
Run  4  320.8   328.9
Run  5  318.2   326.3
Run  6  320.6   328.7
Run  7  316.3   324.4
Run  8  318.4   326.5
Run  9  315.8   323.9
Run 10  339.0   347.1
       ------  ------
        319.9   328.0
Goal Mean Completion Time:    8.1 Sec
```

```
Goal Designation Number: (...325)
Run  1  321.8   410.5
Run  2  315.8   408.6
Run  3  316.9   419.6
Run  4  322.3   416.8
Run  5  319.7   411.4
Run  6  322.1   412.1
Run  7  317.8   420.8
Run  8  319.9   419.3
Run  9  317.3   407.8
Run 10  340.5   451.2
       ------  ------
        321.4   417.8
Goal Mean Completion Time:   96.4 Sec

Goal Designation Number: (...335)
Run  1  366.8   425.6
Run  2  360.8   421.4
Run  3  361.9   420.1
Run  4  367.3   417.8
Run  5  364.7   424.0
Run  6  367.1   413.8
Run  7  362.8   434.6
Run  8  364.9   421.0
Run  9  362.3   421.9
Run 10  385.5   436.5
       ------  ------
        366.4   423.7
Goal Mean Completion Time:   57.3 Sec

Goal Designation Number: (...355)
Run  1  399.2   421.1
Run  2  393.2   419.8
Run  3  394.3   419.6
Run  4  399.7   443.4
Run  5  397.1   422.3
Run  6  399.5   426.6
Run  7  395.2   420.8
Run  8  397.3   419.3
Run  9  394.7   419.4
Run 10  417.9   451.2
       ------  ------
        398.8   426.3
Goal Mean Completion Time:   27.5 Sec
```

```
Goal Designation Number: (...366)
Run  1  409.5   572.1
Run  2  407.6   537.0
Run  3  418.6   575.9
Run  4  415.8   552.6
Run  5  410.4   518.3
Run  6  411.1   588.9
Run  7  419.8   542.8
Run  8  418.3   526.1
Run  9  406.8   579.8
Run 10  450.2   582.1
       ------  ------
        416.8   557.6
Goal Mean Completion Time:  140.8 Sec

Goal Designation Number: (...368)
Run  1  462.3   480.8
Run  2  459.8   481.1
Run  3  457.6   477.2
Run  4  462.7   480.8
Run  5  463.6   482.0
Run  6  464.4   492.3
Run  7  461.1   480.0
Run  8  459.4   477.0
Run  9  459.7   477.5
Run 10  481.0   501.6
       ------  ------
        463.1   483.0
Goal Mean Completion Time:   19.9 Sec

Goal Designation Number: (...375)
Run  1  423.6   529.2
Run  2  420.3   522.5
Run  3  418.2   519.5
Run  4  415.3   522.8
Run  5  422.3   524.7
Run  6  411.1   531.4
Run  7  433.6   535.6
Run  8  419.4   527.4
Run  9  420.9   532.8
Run 10  434.2   544.6
       ------  ------
        421.9   529.1
Goal Mean Completion Time:  107.2 Sec
```

```
Goal Designation Number: (...385)
Run  1  444.7  1078.4
Run  2  438.7  1057.3
Run  3  439.8  1065.9
Run  4  445.2  1066.2
Run  5  442.6  1075.2
Run  6  445.0  1082.0
Run  7  440.7  1098.5
Run  8  442.8  1062.1
Run  9  440.2  1089.1
Run 10  463.4  1097.0
       ------  ------
        444.3  1077.2
Goal Mean Completion Time:  632.9 Sec

Goal Designation Number: (...410)
Run  1  493.8   542.3
Run  2  485.0   538.9
Run  3  484.1   532.8
Run  4  485.4   534.5
Run  5  488.4   537.4
Run  6  496.1   548.7
Run  7  500.4   557.7
Run  8  491.9   541.5
Run  9  498.1   548.4
Run 10  505.3   564.7
       ------  ------
        492.9   544.7
Goal Mean Completion Time:   51.8 Sec

Goal Designation Number: (...427)
Run  1  541.3   562.4
Run  2  537.9   565.2
Run  3  531.3   558.1
Run  4  533.5   556.1
Run  5  533.8   559.2
Run  6  547.7   575.1
Run  7  548.7   578.2
Run  8  540.5   562.2
Run  9  547.4   569.6
Run 10  563.7   590.2
       ------  ------
        542.6   567.6
Goal Mean Completion Time:   25.1 Sec
```

```
Goal Designation Number: (...438)
Run  1  561.4   576.4
Run  2  558.4   573.6
Run  3  553.5   568.7
Run  4  555.1   570.1
Run  5  558.2   573.2
Run  6  570.1   585.3
Run  7  577.2   592.2
Run  8  561.2   576.2
Run  9  568.6   583.6
Run 10  586.7   603.6
       ------  ------
        565.0   580.3
Goal Mean Completion Time:   15.3 Sec

Goal Designation Number: (...444)
Run  1  575.4   588.9
Run  2  572.4   585.8
Run  3  567.5   581.0
Run  4  569.1   582.6
Run  5  572.2   585.7
Run  6  584.1   597.6
Run  7  591.2   604.6
Run  8  575.2   588.6
Run  9  582.6   596.1
Run 10  600.7   614.2
       ------  ------
        579.0   592.5
Goal Mean Completion Time:   13.5 Sec

Goal Designation Number: (...456)
Run  1  575.4   591.9
Run  2  572.4   588.8
Run  3  567.5   583.9
Run  4  569.1   585.6
Run  5  572.2   588.7
Run  6  584.1   600.5
Run  7  591.2   607.6
Run  8  575.2   591.6
Run  9  582.6   599.1
Run 10  600.7   617.2
       ------  ------
        579.0   595.5
Goal Mean Completion Time:   16.4 Sec
```

```
Goal Designation Number: (...460)
Run  1  587.9  1014.9
Run  2  584.8   993.2
Run  3  580.0   998.1
Run  4  581.6  1002.9
Run  5  584.7  1009.5
Run  6  596.6  1016.2
Run  7  603.6  1034.6
Run  8  587.6  1000.0
Run  9  595.1  1020.5
Run 10  613.2  1033.2
       ------  ------
        591.5  1012.3
Goal Mean Completion Time:  420.8 Sec

Goal Designation Number: (...470)
Run  1  650.9   863.4
Run  2  647.8   836.0
Run  3  637.9   875.8
Run  4  640.8   814.5
Run  5  647.7   860.5
Run  6  651.9   891.2
Run  7  658.9   925.9
Run  8  650.6   869.9
Run  9  652.6   872.0
Run 10  675.0   903.2
       ------  ------
        651.4   871.3
Goal Mean Completion Time:  219.8 Sec

Goal Designation Number: (...490)
Run  1  775.9   827.3
Run  2  772.8   829.9
Run  3  768.0   819.4
Run  4  769.6   821.0
Run  5  772.7   824.1
Run  6  784.6   836.0
Run  7  791.6   843.0
Run  8  775.6   840.1
Run  9  783.1   834.5
Run 10  801.2   852.6
       ------  ------
        779.5   832.8
Goal Mean Completion Time:   53.3 Sec
```

```
Goal Designation Number: (...510)
Run  1  761.2   884.4
Run  2  758.1   866.3
Run  3  748.2   870.1
Run  4  751.1   878.6
Run  5  758.0   877.3
Run  6  762.2   885.0
Run  7  769.2   899.5
Run  8  760.9   872.3
Run  9  762.9   887.5
Run 10  785.3   903.1
       ------  ------
        761.7   882.4
Goal Mean Completion Time:  120.7 Sec

Goal Designation Number: (...524)
Run  1  750.5   933.3
Run  2  737.7   913.0
Run  3  739.4   919.6
Run  4  743.8   926.4
Run  5  742.2   924.5
Run  6  748.5   935.2
Run  7  751.7   949.5
Run  8  752.5   920.8
Run  9  745.3   934.1
Run 10  781.0   950.6
       ------  ------
        749.3   930.7
Goal Mean Completion Time:  181.5 Sec

Goal Designation Number: (...526)
Run  1  791.9   857.8
Run  2  788.8   840.1
Run  3  784.0   843.9
Run  4  785.6   851.6
Run  5  788.7   850.4
Run  6  800.6   858.6
Run  7  807.6   872.5
Run  8  791.6   845.3
Run  9  799.1   860.5
Run 10  817.2   876.1
       ------  ------
        795.5   855.7
Goal Mean Completion Time:   60.2 Sec
```

```
Goal Designation Number: (...550)
Run  1  856.8   939.1
Run  2  839.1   917.6
Run  3  842.9   926.1
Run  4  850.6   930.7
Run  5  849.4   930.7
Run  6  857.6   941.9
Run  7  871.5   953.2
Run  8  844.3   925.1
Run  9  859.5   941.5
Run 10  875.1   956.4
       ------  ------
        854.7   936.2
Goal Mean Completion Time:   81.5 Sec

Goal Designation Number: (...556)
Run  1 1021.9  1049.5
Run  2 1000.2  1027.8
Run  3 1005.1  1032.7
Run  4 1009.9  1037.5
Run  5 1016.5  1044.1
Run  6 1023.2  1050.8
Run  7 1041.6  1069.2
Run  8 1007.0  1034.6
Run  9 1027.5  1055.1
Run 10 1040.2  1067.8
       ------  ------
       1019.3  1046.9
Goal Mean Completion Time:   27.6 Sec

Goal Designation Number: (...560)
Run  1  862.8  1022.9
Run  2  845.1  1001.2
Run  3  848.9  1006.1
Run  4  856.6  1010.9
Run  5  855.4  1017.5
Run  6  863.6  1024.2
Run  7  877.5  1042.6
Run  8  850.3  1008.0
Run  9  865.5  1028.5
Run 10  881.1  1041.2
       ------  ------
        860.7  1020.3
Goal Mean Completion Time:  159.6 Sec
```

```
Goal Designation Number: (...574)
Run  1 1045.9  1078.4
Run  2 1024.2  1057.3
Run  3 1029.1  1065.9
Run  4 1033.9  1066.2
Run  5 1040.5  1075.2
Run  6 1047.2  1082.0
Run  7 1065.6  1098.5
Run  8 1031.0  1062.1
Run  9 1051.5  1089.1
Run 10 1064.2  1097.0
       ------  ------
       1043.3  1077.2
Goal Mean Completion Time:   33.9 Sec
```